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Fujimoto et al.

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[45] **Date of Patent: Sep. 30, 1997**

[54] COATING APPARATUS

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[73] Assignees: **Tokyo Electron Limited**, Tokyo; **Tokyo Electron Kyushu Limited**, Tosu, both of Japan

[21] Appl. No.: **533,396**

[22] Filed: **Sep. 25, 1995**

[30] **Foreign Application Priority Data**

Sep. 29, 1994 [JP] Japan 6-259154

[51] **Int. Cl.**[6] **B05C 11/02**; B05B 13/02

[52] **U.S. Cl.** **118/52**; 118/319; 118/320

[58] **Field of Search** 134/198, 902; 414/935; 141/44, 250, 266, 270, 379, 52; 118/52, 54, 319, 320, 696, 706; 239/140, 149, 159, 160, 164, 165, 170; 222/160

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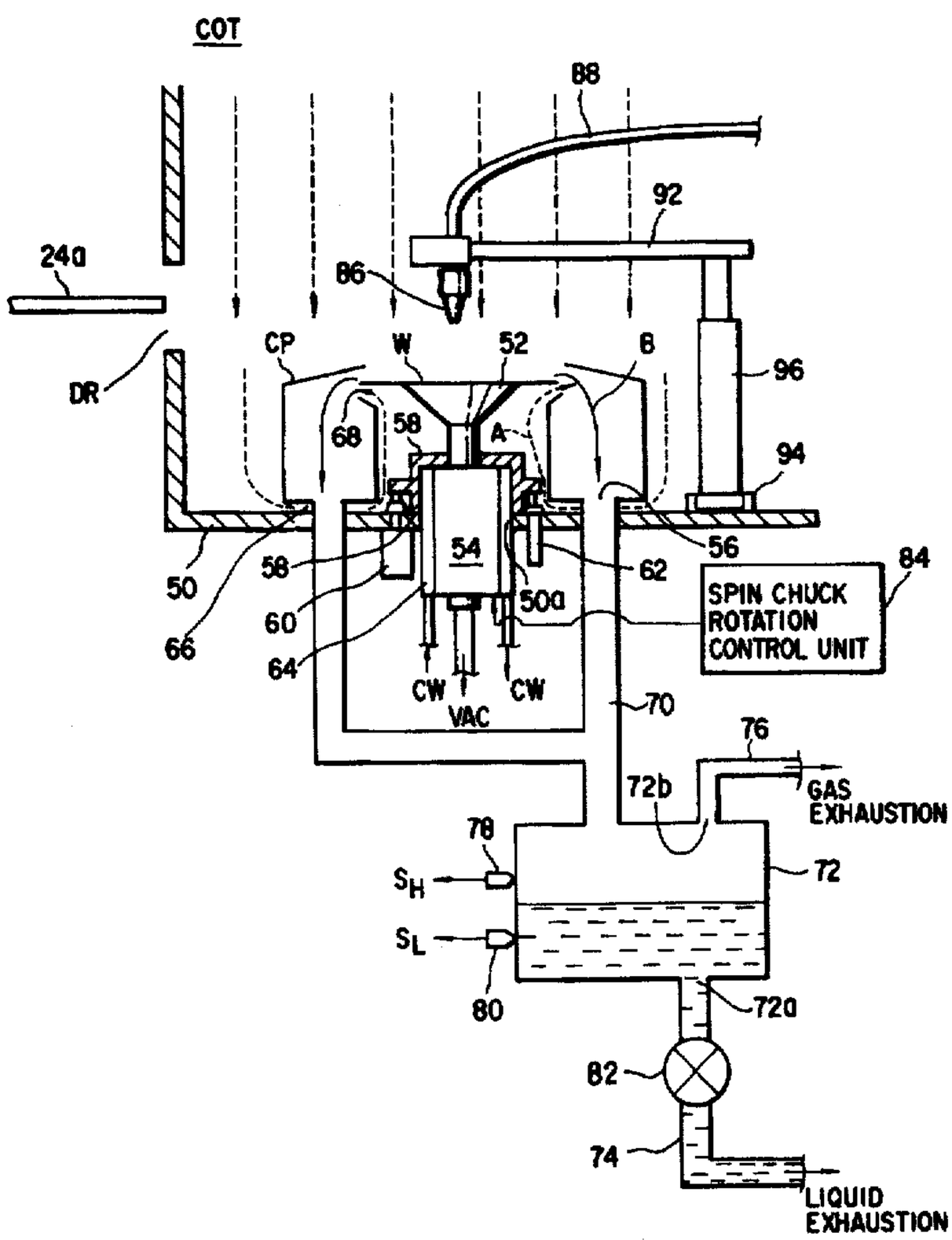
Primary Examiner—Donald E. Czaja
Assistant Examiner—Calvin Padgett
Attorney, Agent, or Firm—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

[57] **ABSTRACT**

According to the present invention, there is provided an coating apparatus including means for holding an object to be process, the object holding means rotating in a state in which the object is placed thereon, a ring-like cup situated on an outer side of the object holding means, processing solution supply means, provided above the object, for supplying a processing solution on a surface of the object, discharge means, provided underneath the ring-like cup, for discharging processing solution portions scattered around when the processing solution is supplied on the surface of the object as a waste solution, together with a gas, and storage means, connected to the discharge means, for storing the waste solution and the gas discharged from the discharge means, wherein the waste solution and the gas are separated from each other in the storage means.

13 Claims, 11 Drawing Sheets



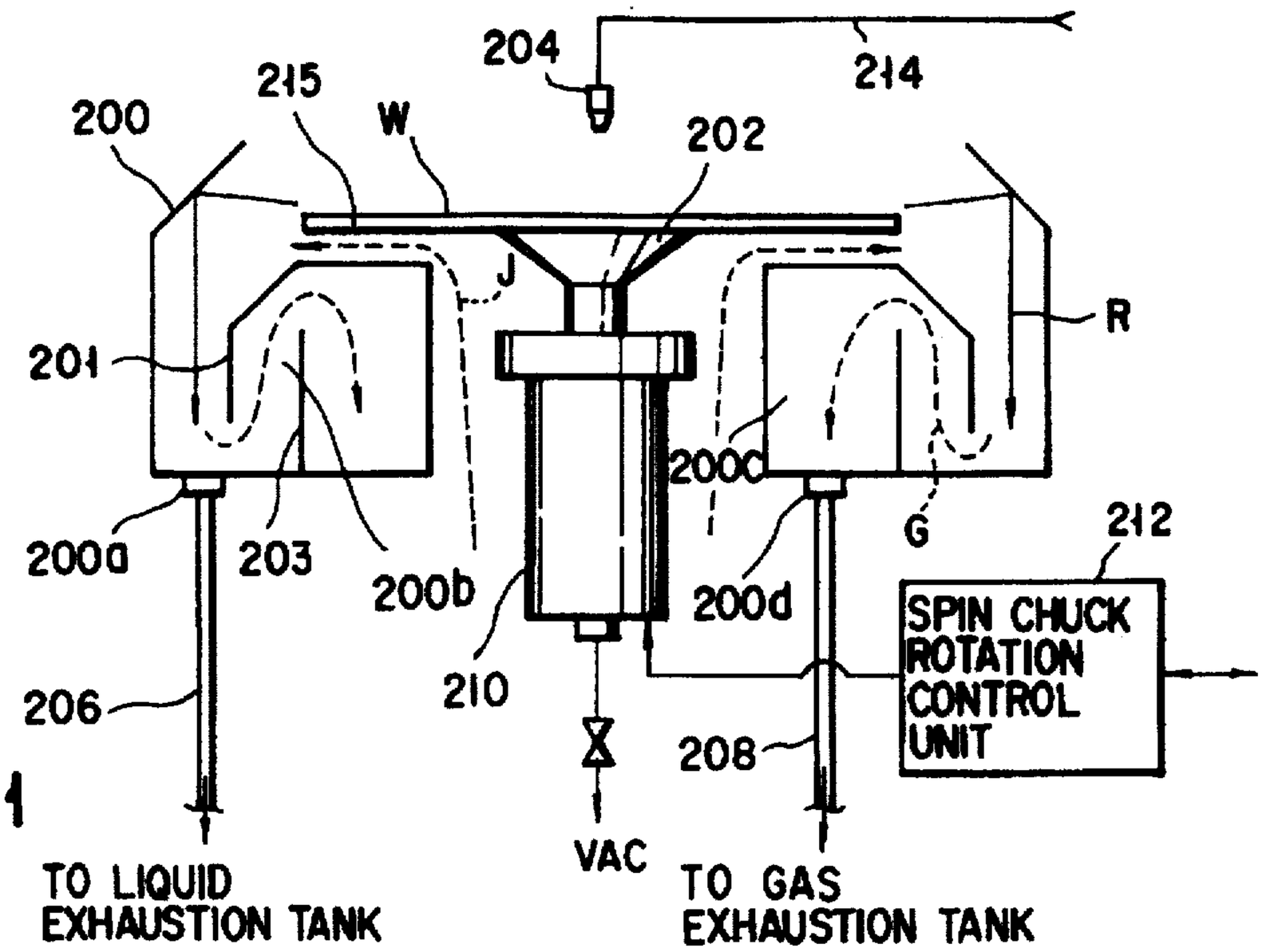


FIG. 1
PRIOR ART

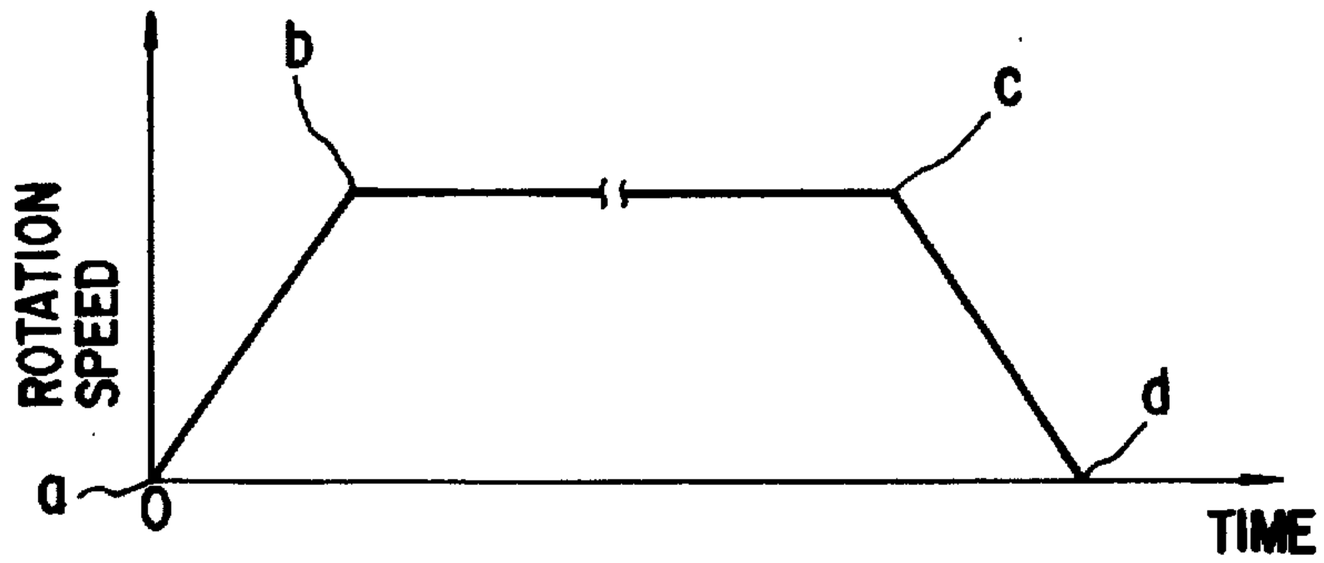


FIG. 2
PRIOR ART

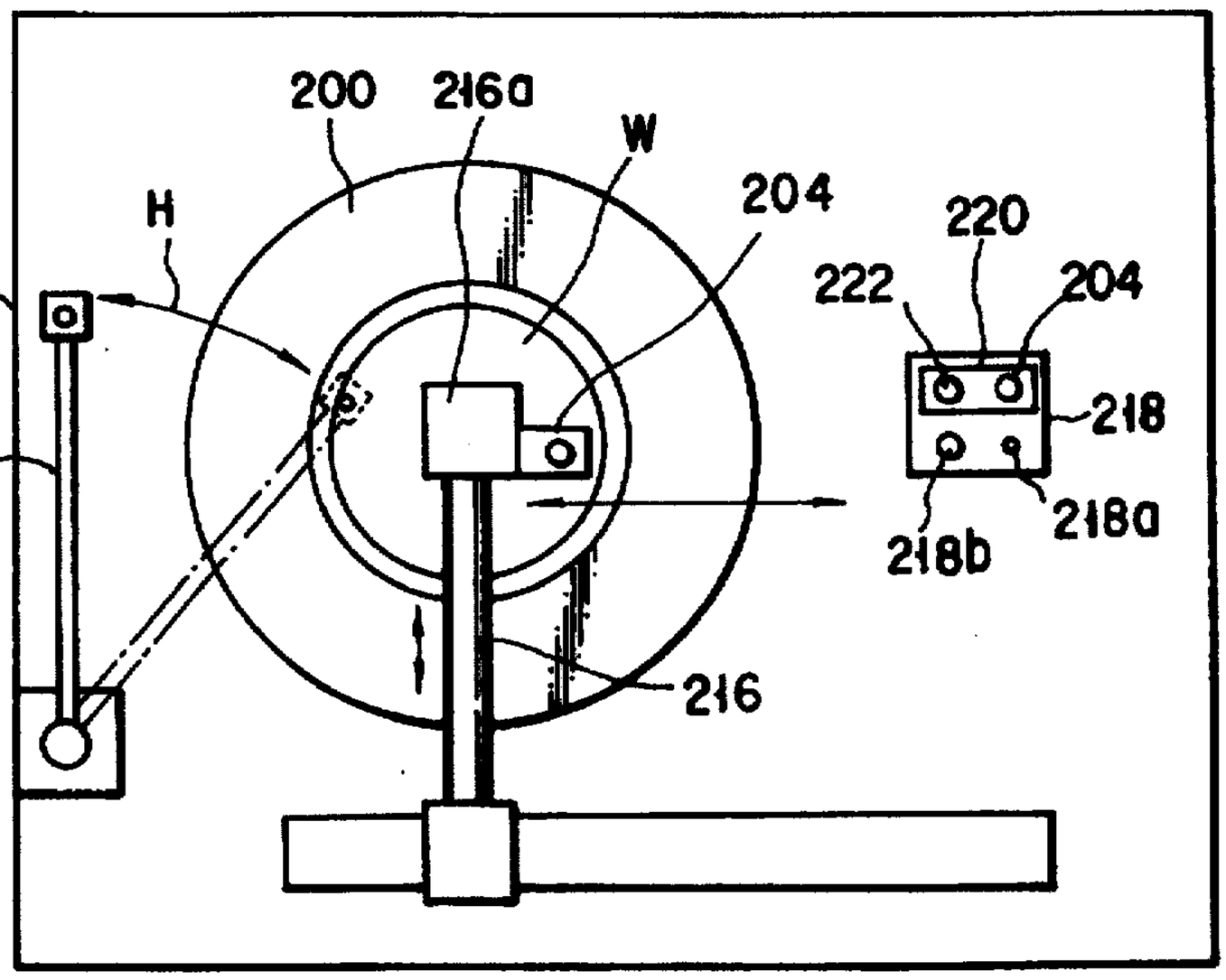


FIG. 3
PRIOR ART

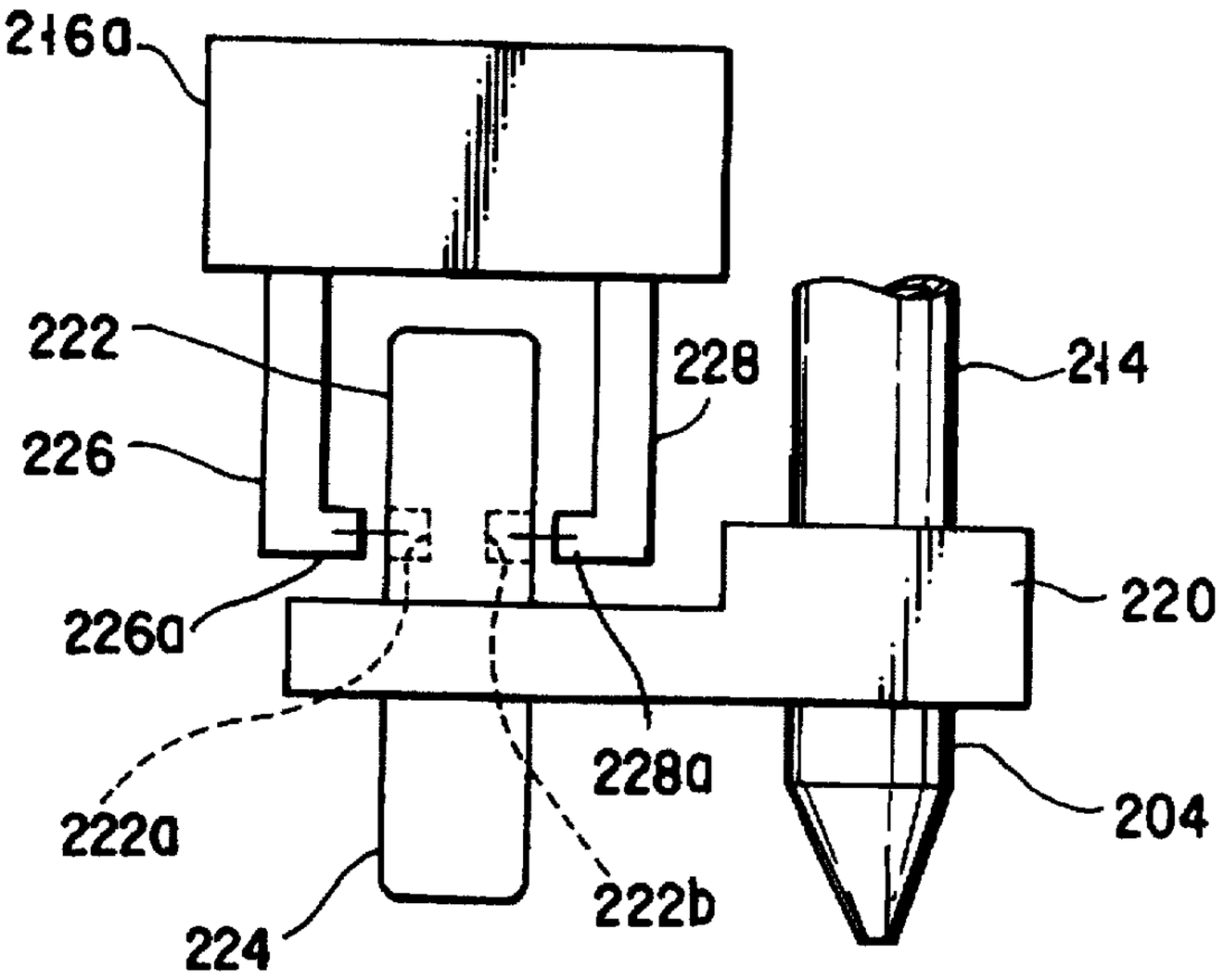


FIG. 4
PRIOR ART

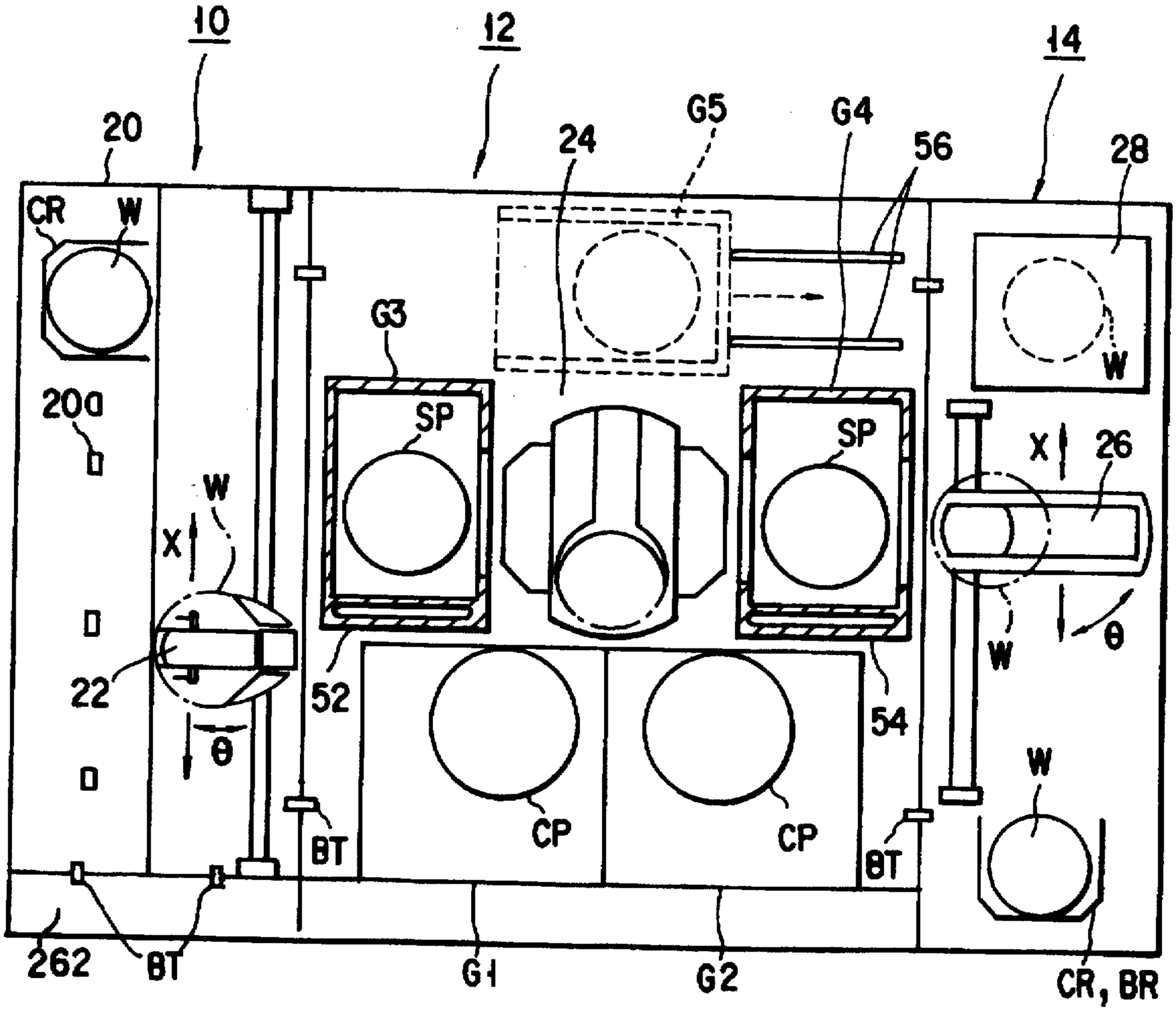


FIG. 5

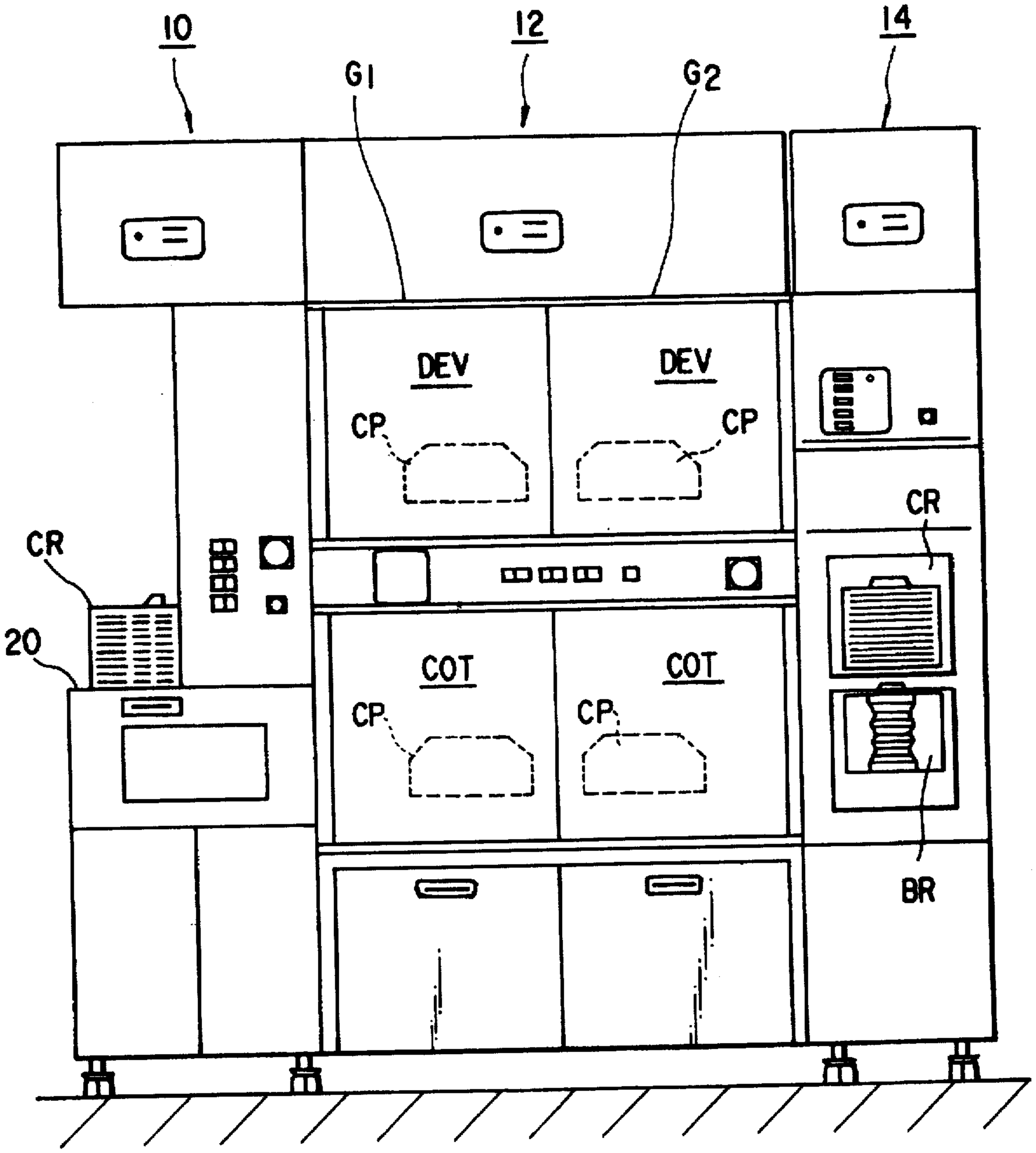


FIG. 6

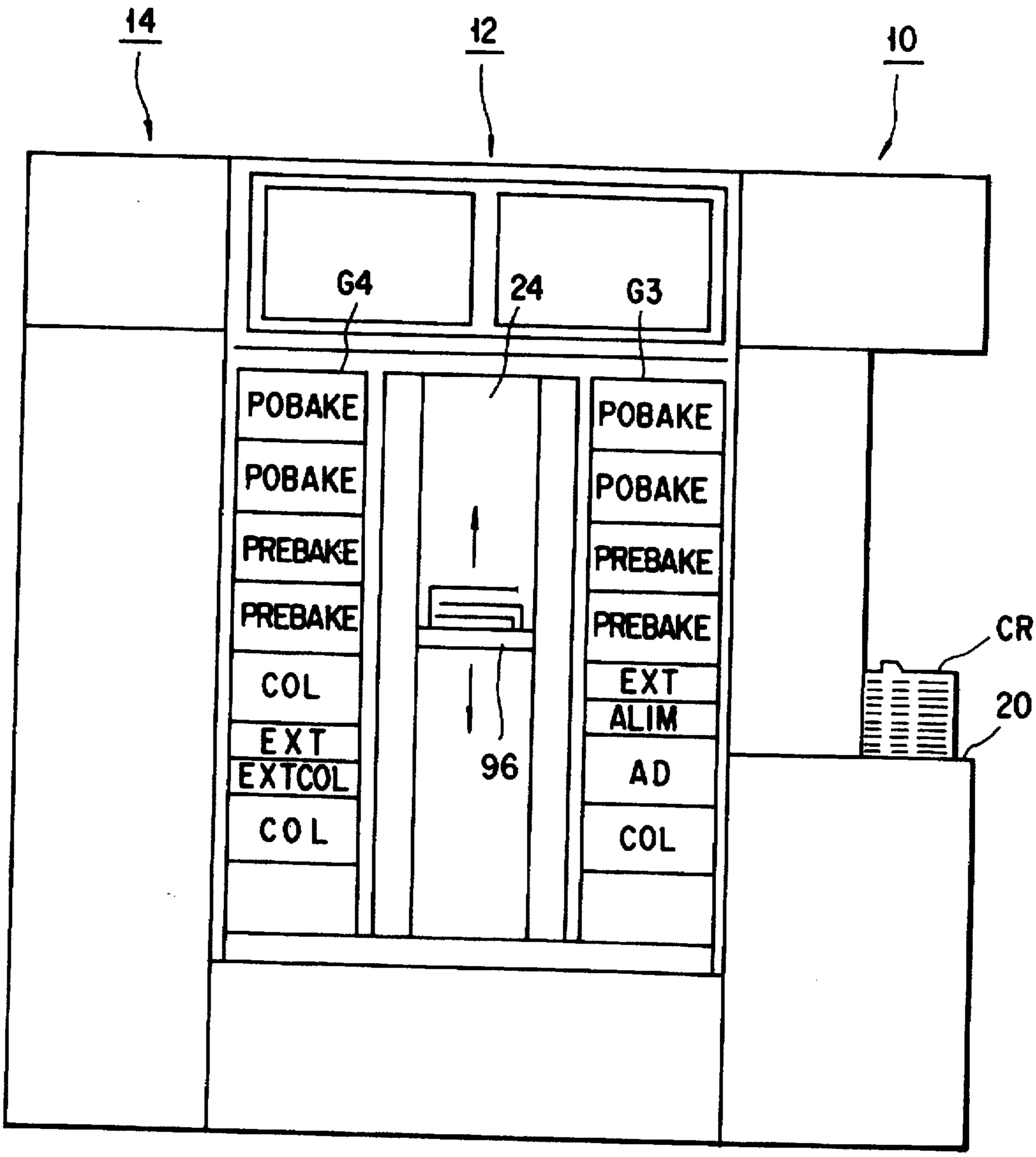

14
12
10
G4
24
G3
POBAKE
POBAKE
PREBAKE
PREBAKE
COL
EXT
EXTCOL
COL
96
POBAKE
POBAKE
PREBAKE
PREBAKE
EXT
ALIM
AD
COL
CR
20

FIG. 7

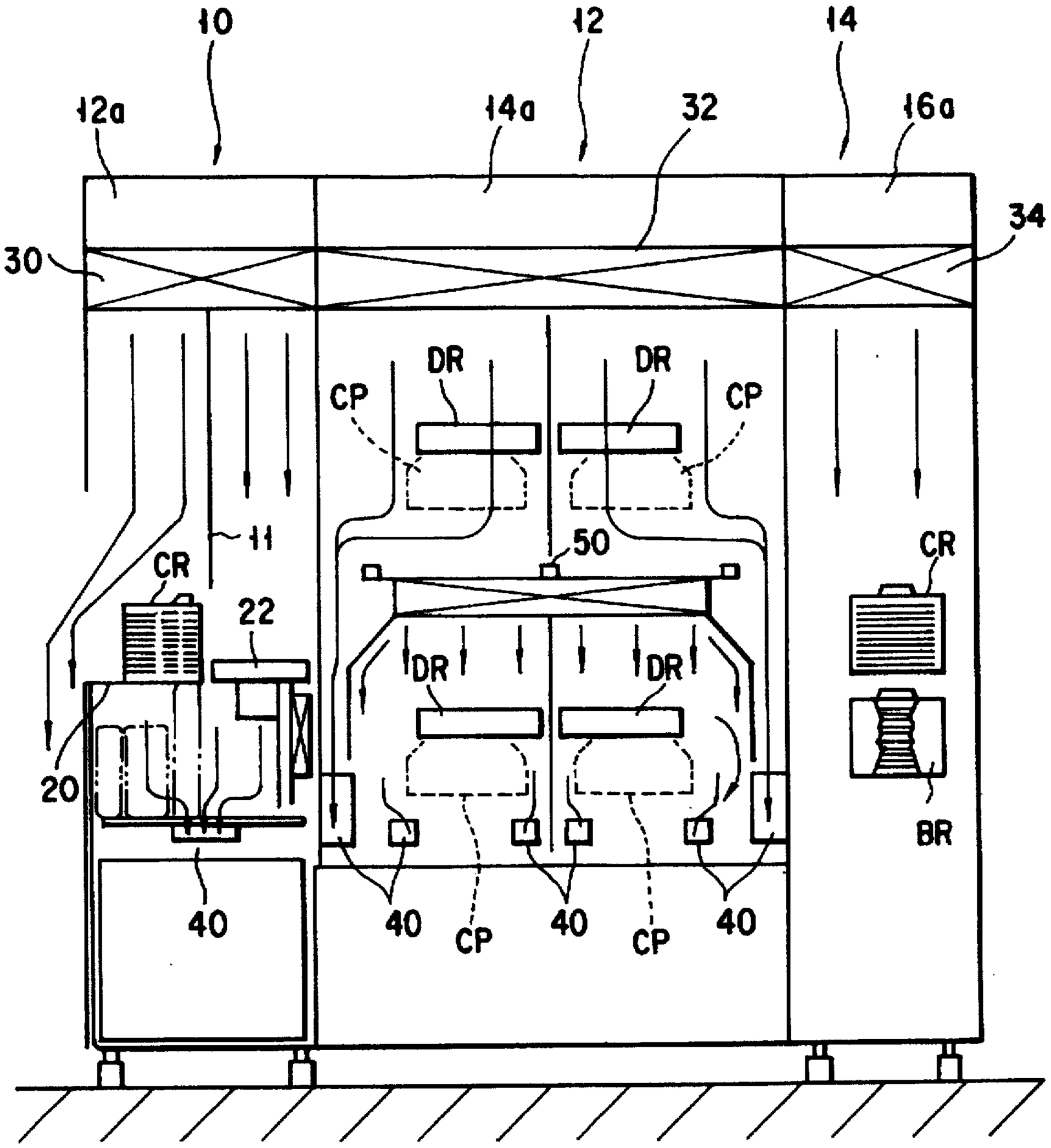

10
12
14
12a
14a
32
16a
34
30
DR
DR
CP
CP
11
50
CR
CR
22
DR
DR
20
BR
40
40
CP
40
CP
40

FIG. 8

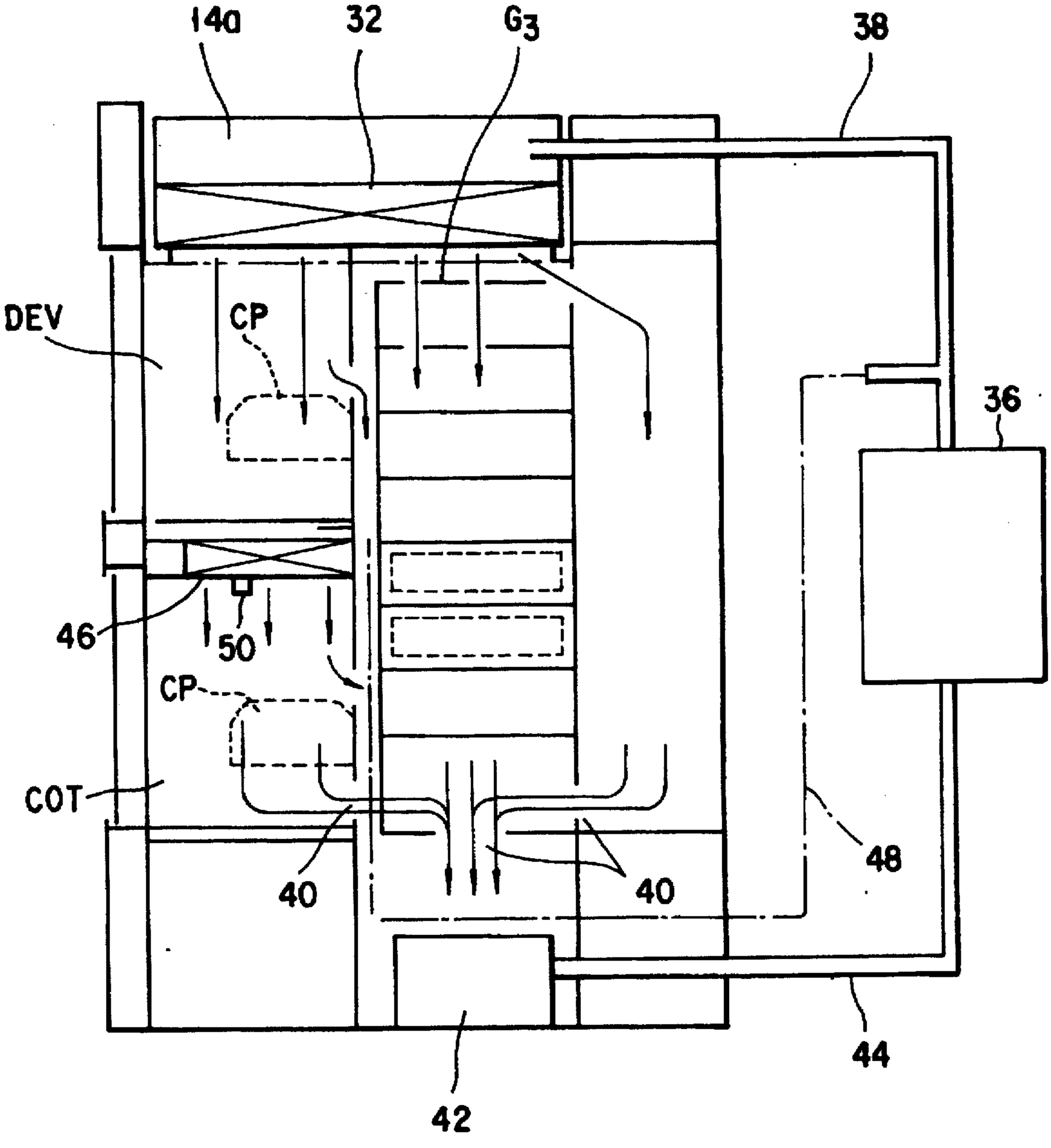


FIG. 9

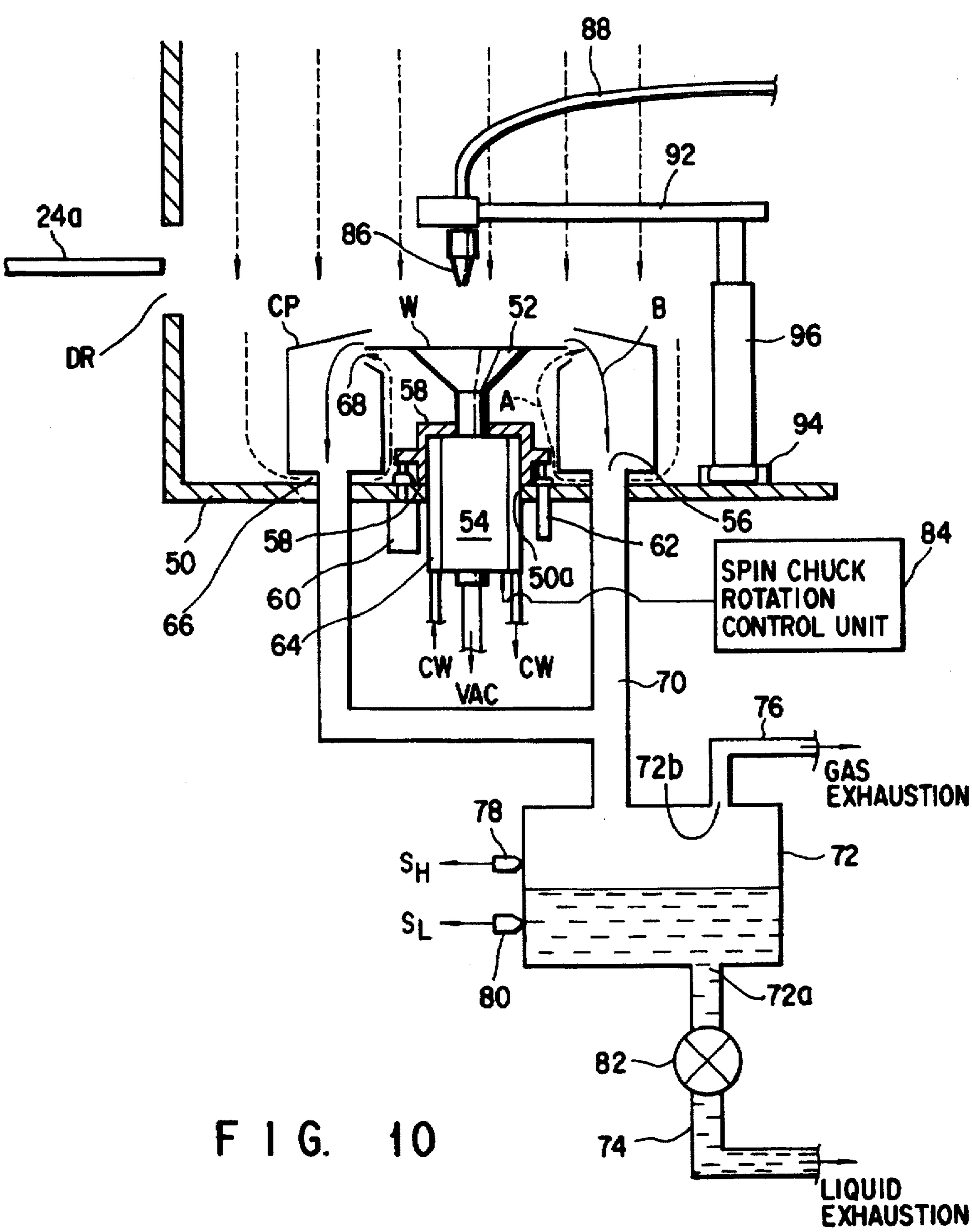

COT
88
92
240
86
CP
W
52
B
DR
96
68
58
A
94
54
56
58
62
50
84
SPIN CHUCK ROTATION CONTROL UNIT
60
50a
66
64
CW
CW
VAC
70
76
72b
GAS EXHAUSTION
78
72
S_H
S_L
80
72a
82
74
LIQUID EXHAUSTION

FIG. 10

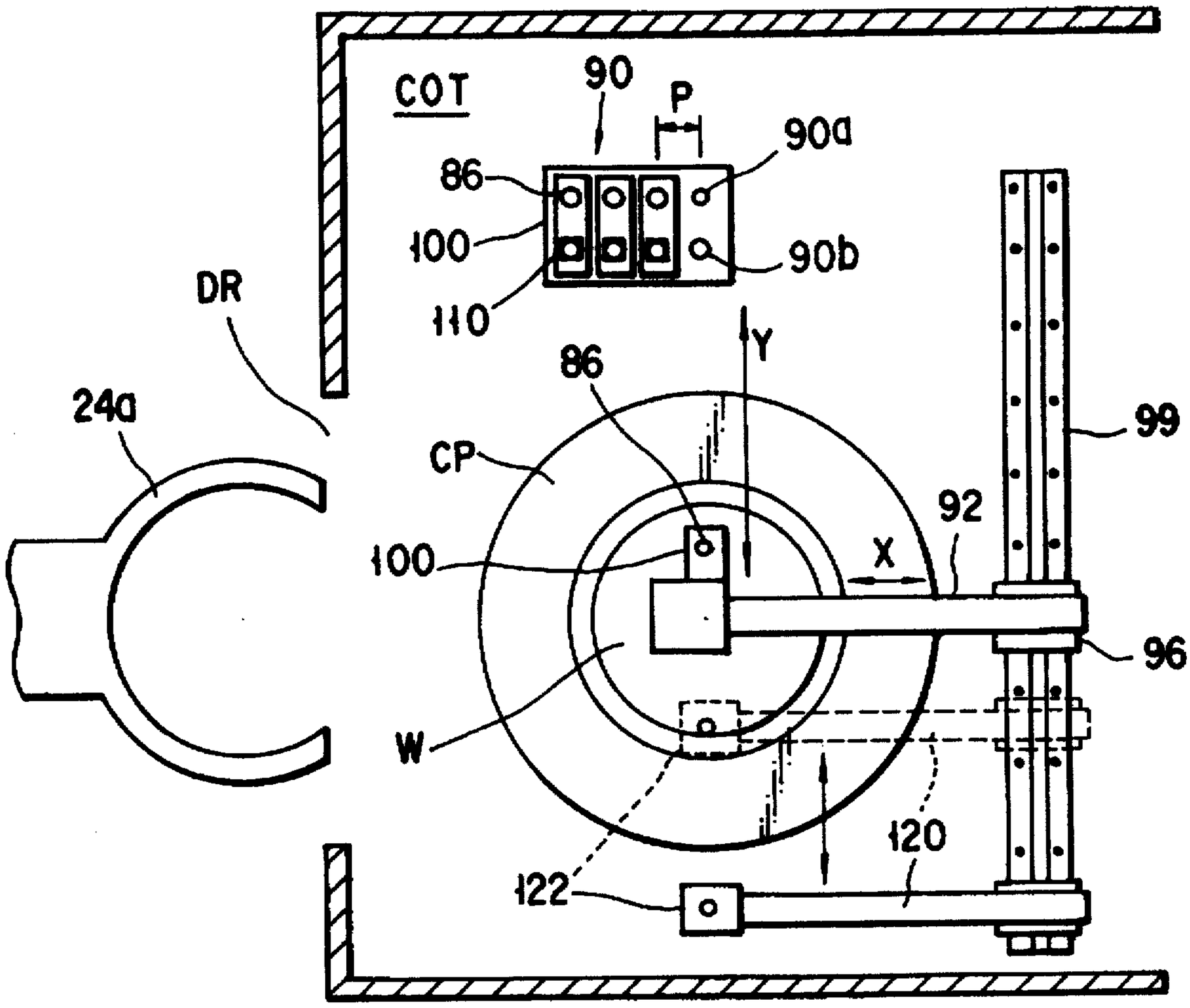

COT
90
P
90a
86
100
90b
110
DR
240
Y
86
CP
99
92
100
X
96
W
120
122

FIG. 11

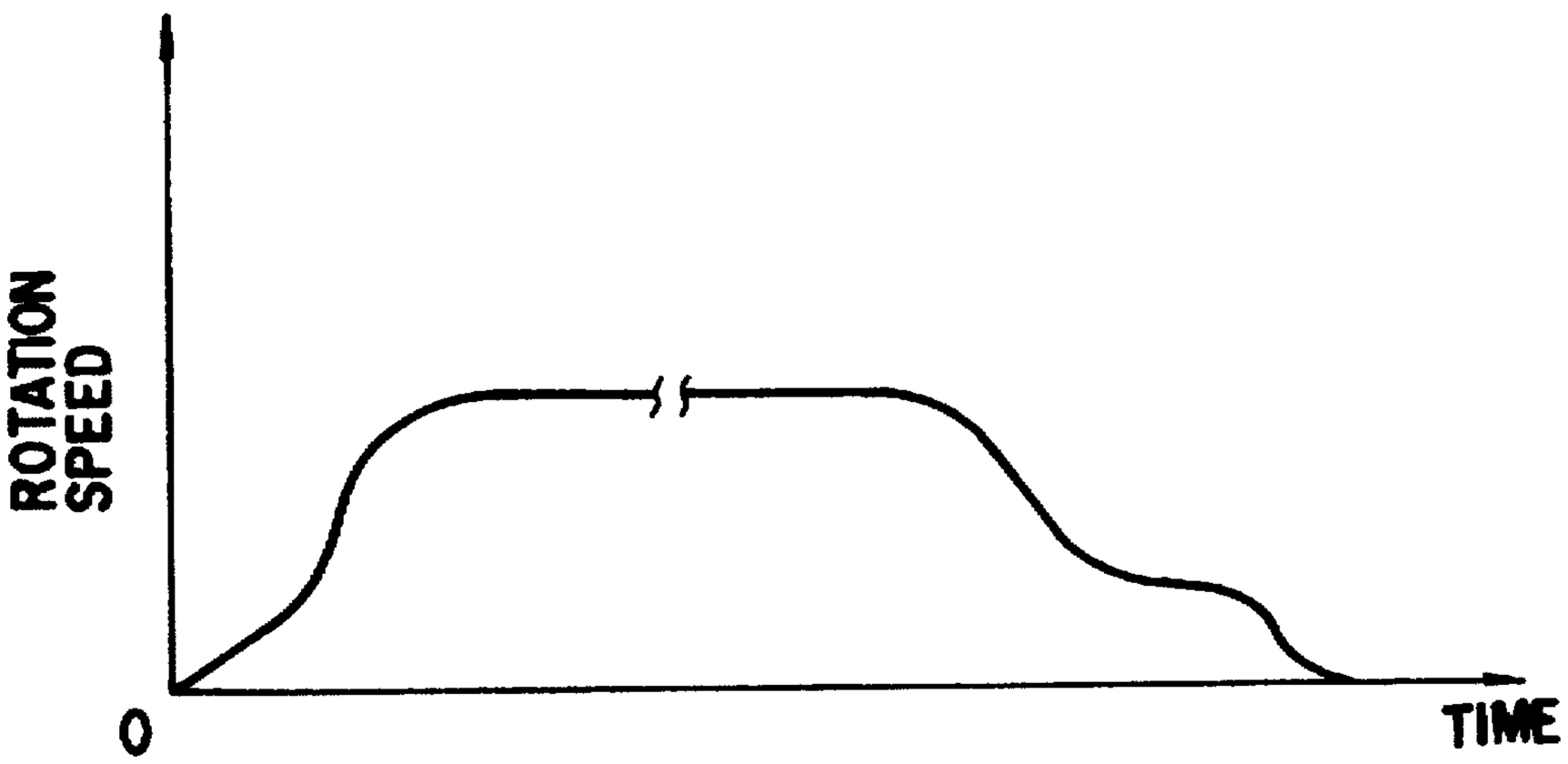

ROTATION SPEED
0
TIME

FIG. 12

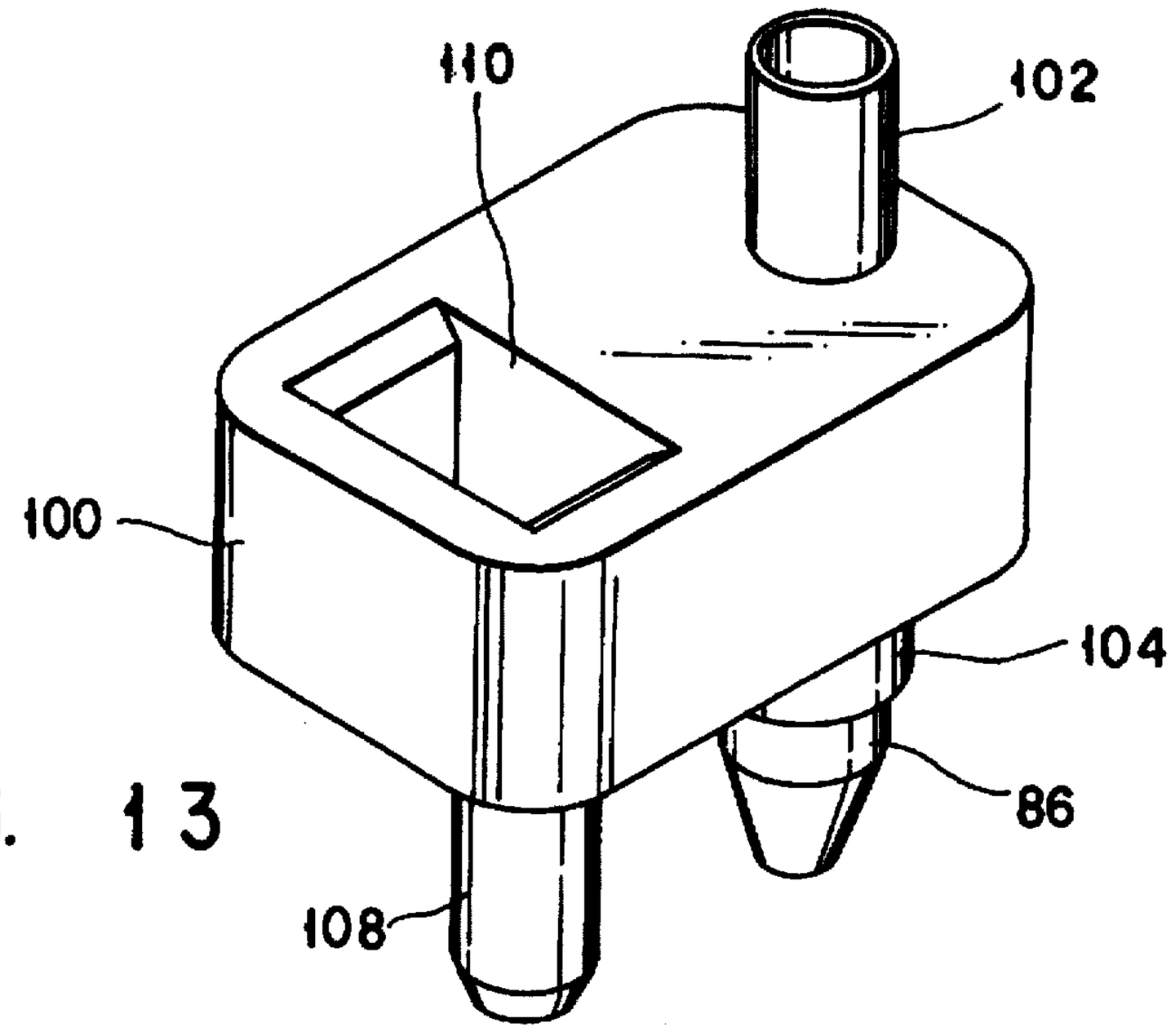


FIG. 13

FIG. 14

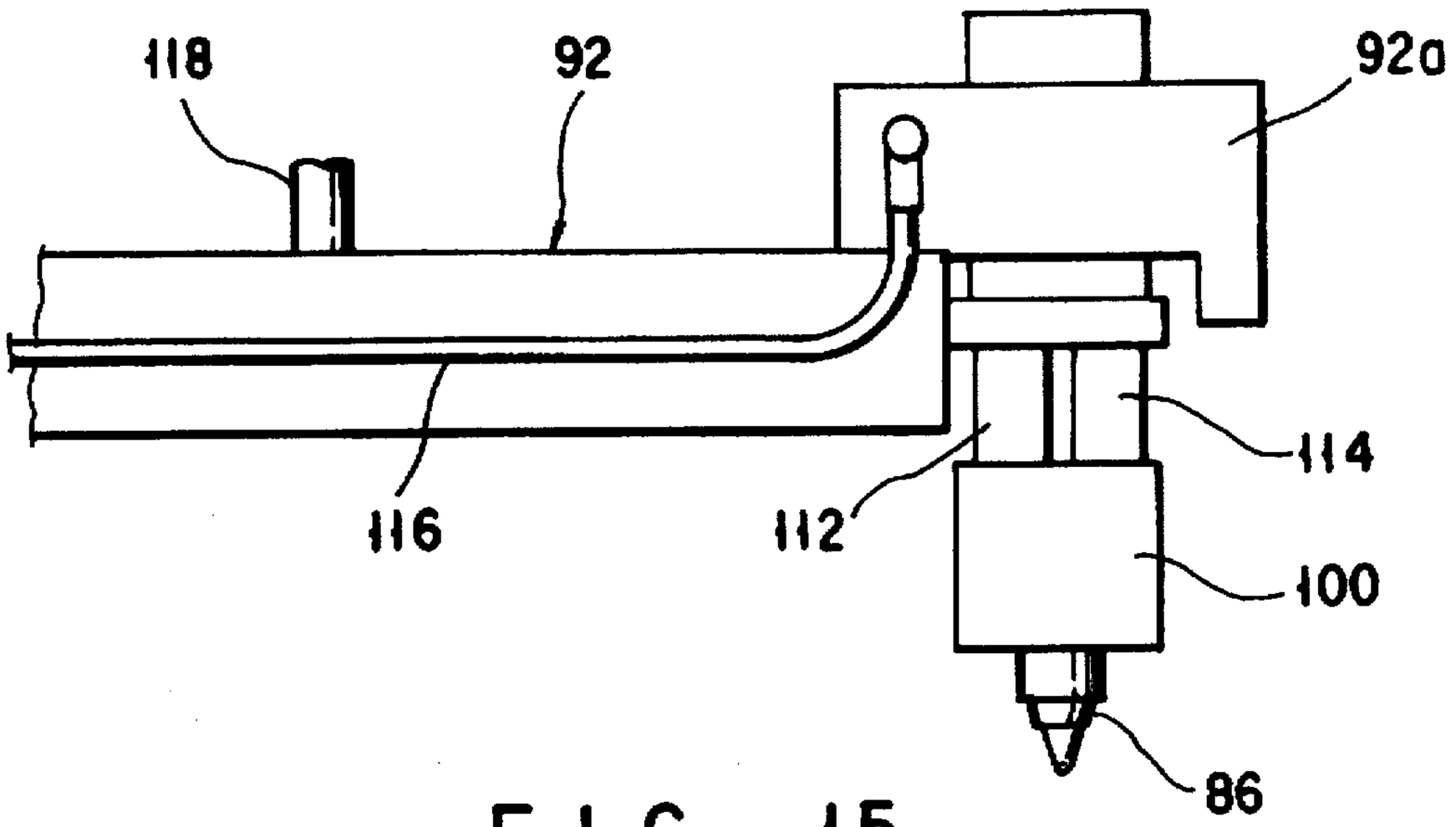


FIG. 15

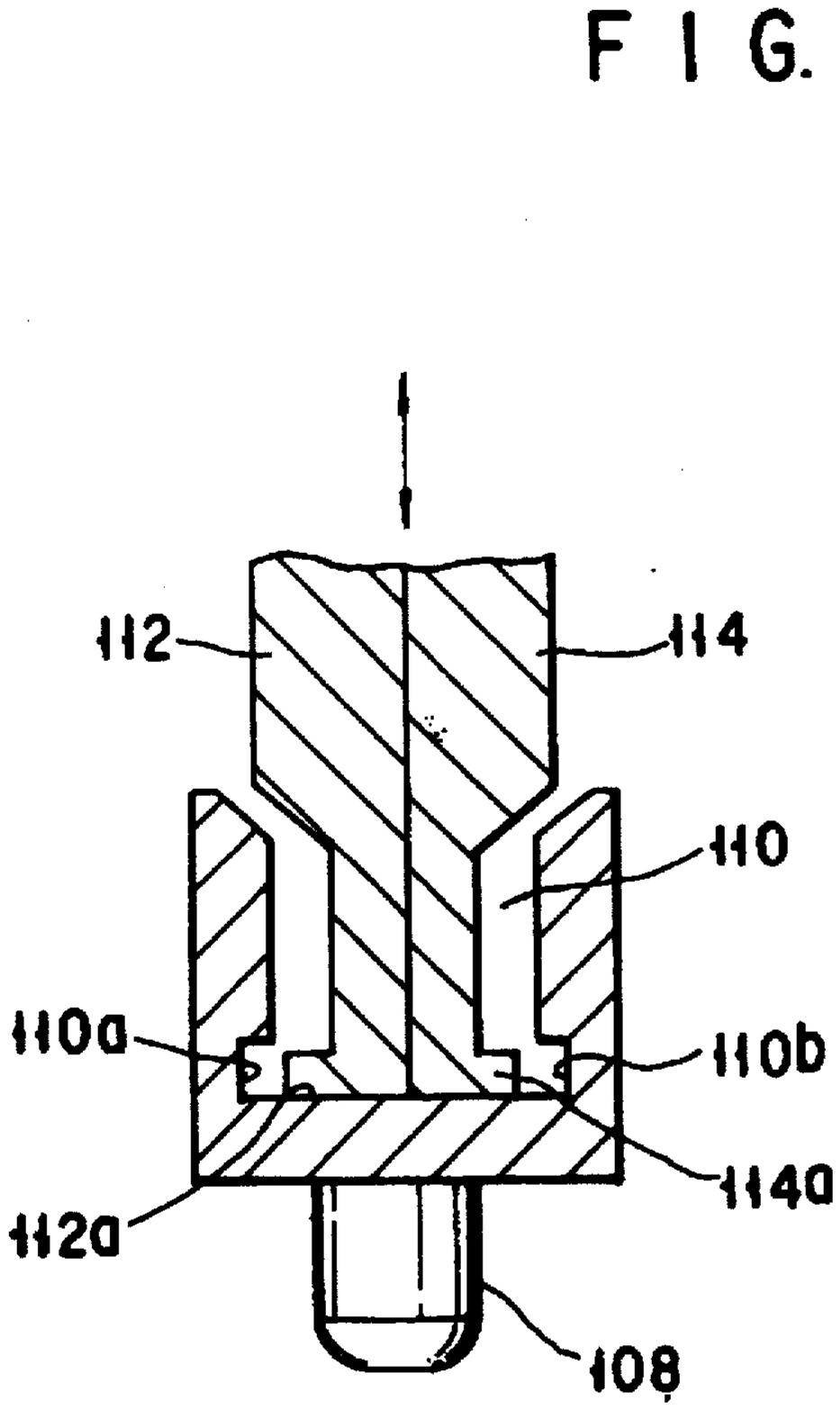


FIG. 16A

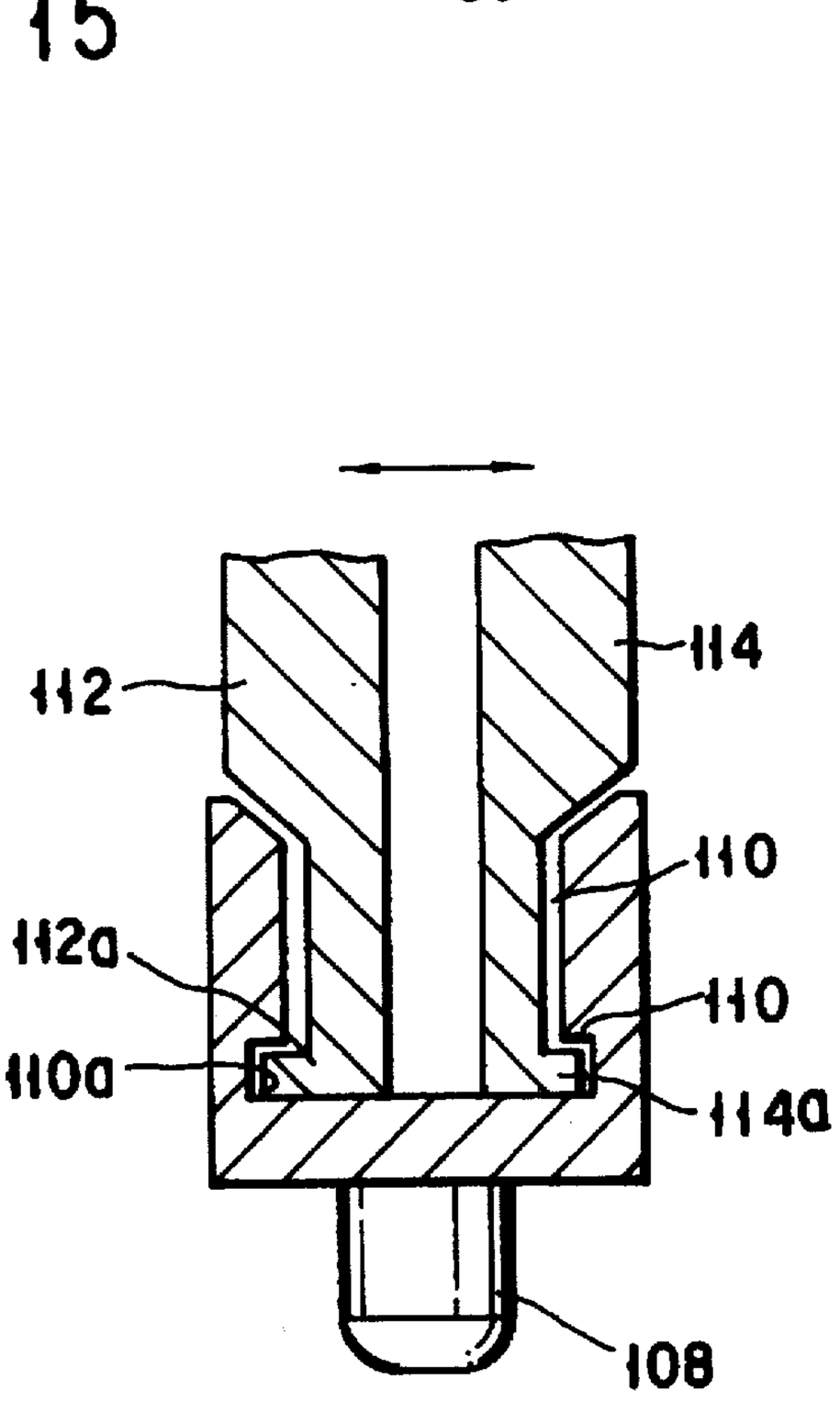


FIG. 16B

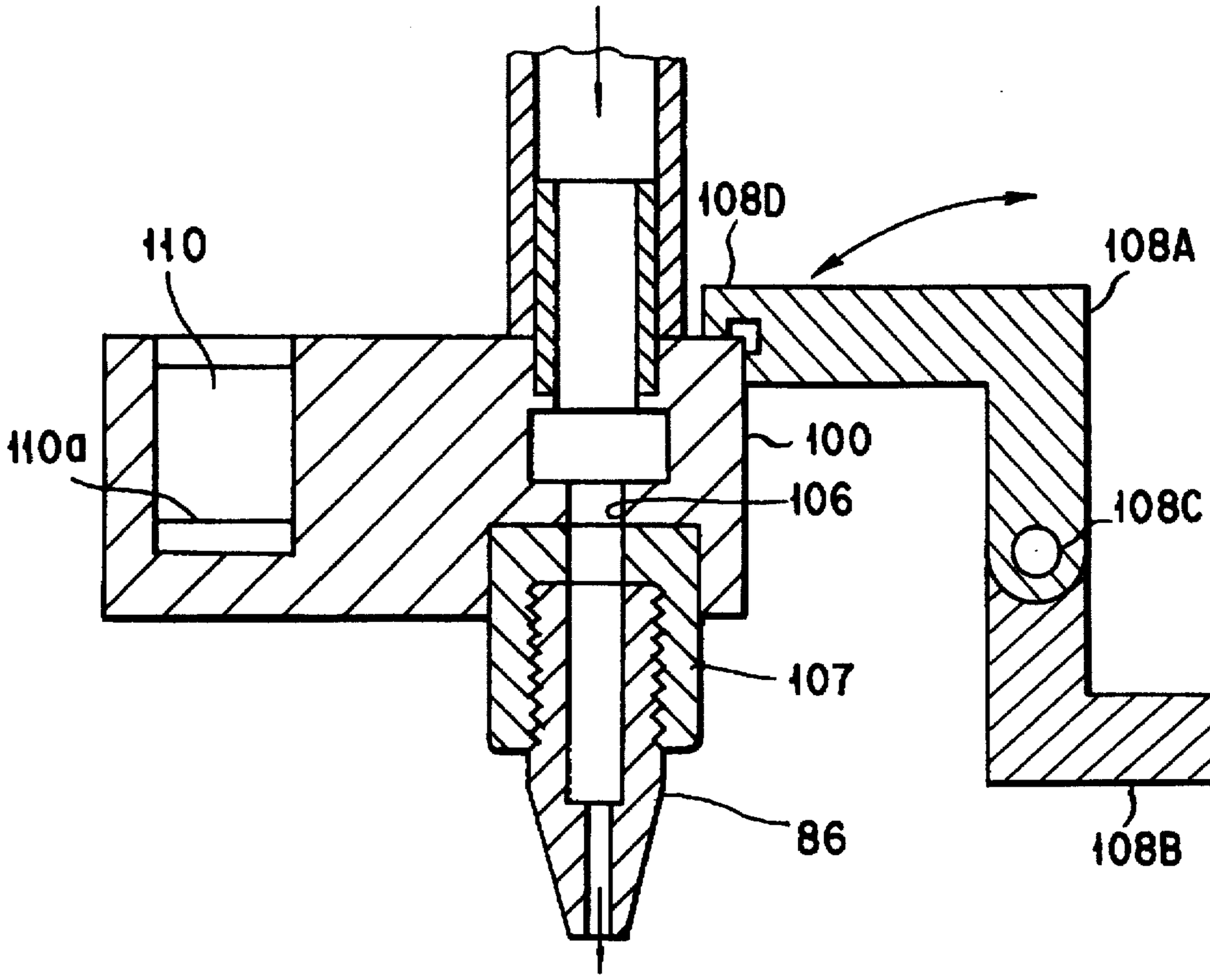


FIG. 17

COATING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an coating apparatus, and more specifically, to a spinner-type coating apparatus which applies processing liquid on a surface of an object to be processed, while the object being held on a spin chuck.

2. Description of the Related Art

An example of the coating apparatus of the above-described type, is a resist coating apparatus for applying resist liquid on a surface of a semiconductor wafer (to be abbreviated as wafer hereinafter) in, for example, a semiconductor manufacture step. A conventional resist coating apparatus will now be described with reference to FIGS. **1** to **4**. FIG. **1** is a cross section schematically showing the structure of a conventional resist coating apparatus. FIG. **2** is a characteristic diagram illustrating the rotation speed of the spin chuck while performing a resist application by means of the resist coating apparatus. FIG. **3** is a schematic plan view showing the structure of the resist coating apparatus. FIG. **4** is a schematic side view showing the structural mechanism for mounting the resist nozzle holder detachably on the resist nozzle scan arm in the resist coating apparatus.

In this resist coating apparatus, a spin chuck **202** is provided at a central portion of an inner section of a ring cup **200**, and a wafer W is placed on the spin chuck **202**. A drop of a resist solution, which is obtained by dissolving a resist into a solvent such as a thinner, is applied from above on the surface of the wafer W via a resist nozzle **204**, and a wafer W is rotated by rotating the spin chuck. Thus, the drop of the resist solution is dispersed by the centrifugal force, so as to apply the solution uniformly over the entire surface of the wafer.

During the above-described resist application step, the portion of the resist solution is scattered around. The scattered portion of the resist solution hits the upper portion of the inner wall of the cup **200**, and is guided to the bottom of the cup **200** as indicated by a solid line R. Then, the resist solution is sent to a waste solution tank (not shown) from an exhaustion opening **200***a* through a pipe **206**. In the cup **200**, an exhaustion path **200***b* having a labyrinth structure consisting of an intermediate hanging wall **201** and an intermediate upright wall **203**, is provided, and air which is exhausted is guided through an exhaustion path **200***b* to an exhaustion chamber **200**C located in an inner side of the cup as indicated by dotted line G, and then sent to an exhaustion pump (not shown) from an exhaustion opening **200***d* of the exhaustion chamber **200***b* through a pipe **208**. Further, in order to prevent the resist solution from scattering around the periphery to the rear surface of the wafer during the resist application, a space **215** is provided between the rear surface of the wafer W and the cup **200**, and through which space **215**, air is allowed to flow from the central portion of the wafer towards the peripheral portion thereof as indicated by a dotted line J.

The spin chuck **202** is rotated by the rotation driving force of the drive motor **210** while holding the wafer W fixedly thereon by a vacuum suction. Usually, after a drop of the resist solution is supplied on the surface of the wafer, the rotation speed of the spin chuck **202** is increased linearly from the still state. The drop of the resist solution is spread over the entire surface of the wafer at a predetermined high speed rotation speed (for example, 4000 rpm), and after a predetermined time elapse, the rotation of the spin chuck **202** is stopped. Therefore, the rotation speed of the spin chuck **202** varies to have the characteristics of a trapezoid-shaped waveform along with a time axis as shown in FIG. **2**.

In some cases, the spin chuck **202** is rotated at a low speed (for example, 1000 rpm) from before the dropping of the resist solution on the surface of the wafer, and the speed is switched to a high-speed rotation (4000 rpm) after the dropping of the solution. In such cases, the rotation speed is linearly increased from a low-speed rotation to a high-speed rotation, and therefore the rotation speed is controlled to have substantially the same trapezoid-shaped waveform characteristics as that shown in FIG. **2**. The rotation speed of the spin chuck **202**, that is, the rotation speed of the drive motor **210**, is controlled by a spin chuck rotation control unit **212** under an instruction of a system controller (not shown).

The resist nozzle **204** is connected to a resist supplying unit (not shown) via a resist supplying tube **214**. The resist nozzle **204**, as shown in FIG. **3**, is moved by means of a resist nozzle scan arm **216** between a resist solution discharge position (shown in FIG. **1**) set above the spin chuck **202** and a resist nozzle standby unit provided on the outer side of the cup **200**.

At the resist nozzle stand-by unit **218***a*, the discharge outlet of the resist nozzle **204** is inserted to an opening **218***a* of a solvent atmosphere chamber, in which the outlet is exposed to the solvent, preventing the resist solution at the tip end of the nozzle from being solidified or deteriorated. Usually, a plurality of resist nozzles **204** are provided, and each nozzle is separately used in accordance with the type of resist solution. For this reason, the resist nozzle scan arm **216** is designed so that each of the resist nozzles **204** is detachably set onto the distal end of the arm in order to move it.

Each of the resist nozzles **204**, as shown in FIG. **4**, is fixedly held on a plate-like nozzle holder **220**. To the nozzle holder **220**, the resist supplying tube **214** is set so that it is connected to the resist nozzle **204**. Further, a joint member **222** is integrally formed on the nozzle holder **220** so that the holder can be detachably mounted to the resist nozzle scan arm **216**. Furthermore, a fixation member **224** is integrally formed on the holder **220** so that the holder can be fixed by engagement to a fixation holding hole **218***a* of the resist nozzle standby unit **218**. A pair of holes **222***a* and **222***b* are made in the outer wall surface of the joint member **222** to be located opposite to each other.

A drive mechanism (not shown) is built at a distal end portion **216** of the resist nozzle scan arm **216**. With this drive mechanism, nail portions **226***a* and **228***a* of the end portions of a pair of openable tweezers **226** and **228** are inserted to these holes **222***a* and **222***b* for engagement, and therefore the nozzle holder **220** is set to the resist nozzle scan arm **216**, thus mounting the resist nozzle **204** to the arm.

In the resist coating apparatus of the above-described type, after the application of the resist solution, a rinse solution is supplied to a peripheral portion of the wafer by means of a rinse nozzle which is different from the resist nozzle, so as to dissolve the resist present on that portion, to be removed (side rinse). As can be seen in FIG. **3**, in the conventional apparatus, a rinse nozzle scan arm **230** having a rinse nozzle **230** at its arm distal end portion, is rotated as indicated by an arrow H, and the rinse nozzle **230** is moved between the nozzle standby position located at a side of the cup **200** and a rinse solution discharge position located above the peripheral portion of the wafer W.

In FIG. **1**, the drawing of pipes connected to both nozzles **204** and **230** is omitted to facilitate the illustration.

The above-described conventional resist coating apparatus entails the following drawbacks.

First, in the conventional resist coating apparatus, the resist solution (waste solution) and the gas exhausted are separated from each other within the cup **200**, and they are discarded from the separate exhaustion openings **200***a* and **200***d*. However, mist of the resist solution is also guided along with the gas exhausted to the exhaustion path **200***b*, and adhered on the wall surfaces **201** and **203**. The adhered mist is dried and solidified, stuffing the exhaustion path **200***b* with the resist. In order to avoid this, the exhaustion path **200***b* must be washed frequently with a solvent such as thinner, and therefore the conventional apparatus requires much labor in terms of maintenance and operation.

Second, in the conventional resist coating apparatus, the resist solution is prevented from flowing around the periphery of the wafer and adhering to the rear surface of the wafer by allowing an air flow through the space **215** between the periphery portion of the rear surface of the wafer W and the cup **200** (from the inner side towards the outer side). However, the air of the flow is warmed by the heat of the motor **210** while it is ascending along the side surface of the drive motor **210**. Thus, the warmed air hits the peripheral portion of the rear surface of the wafer W, thus heating that portion regionally. As a result, the uniformity of the resist film thickness is lowered.

Third, in the conventional resist coating apparatus, while increasing or decreasing or switching the rotation speed of the spin chuck **202**, the speed is controlled so as to have a linear function along with the time axis as can be seen in FIG. **2**. For this reason, at points (a, b, c and d) of change in the rotation speed, the acceleration is very high, causing a sliding between the spin chuck **202** and the wafer W. Due to the sliding, particles may be generated.

Fourth, in the conventional resist coating apparatus, as the tweezers **226** and **228** of the resist nozzle scan arm **216** are jointed or connected to the joint member **222** of the nozzle holder **220**, the nail portions **226***a* and **228***b* of the tip ends of the tweezers scrape off the holes **222***a* and **222***b* of the joint member **222**. The scraping off of the holes creates particles, which may be dropped on the wafer W.

Fifth, in the conventional resist coating apparatus having a structure in which the rinse nozzle **232** used for side rinse is moved by the revolving rinse nozzle scan arm **230**, even if there is a slight error in the rotation angle of the arm **230** due to, for example, a backlash within the arm drive mechanism, a large error appears in the distance in the arcing movement of the tip end of the arm. Therefore, it is difficult to position the rinse nozzle **232** accurately at a predetermined rinse solution discharge position. In the case where the rinse nozzle **232** is displaced from the rinse solution discharge position, the precision?? of the side rinse is deteriorated, leaving some resist out on the peripheral portion of the wafer W. This results in that the conveying arm is brought into contact with the resist film when holding the peripheral portion of the wafer W, which scrapes off the resist film portions adhered to the conveying arm, creating the problem of particles.

SUMMARY OF THE INVENTION

The first object of the present invention is to provide an coating apparatus having an improved maintenance characteristic, in which solidification of the processing solution in the cup for collecting the processing solution scattering while supplying the solution to an object to be processed, or stuffing of the member with the solidified solution is prevented.

According to the first object of the present invention, there is provided an coating apparatus comprising: means for holding an object to be process, the object holding means rotating in a state in which the object is placed thereon; a ring-shaped cup situated on an outer side of the object holding means; processing solution supply means, provided above the object, for supplying a processing solution on a surface of the object; discharge means, provided underneath the ring-shaped cup, for discharging processing solution portions scattered around when the processing solution is supplied on the surface of the object as a waste solution, together with a gas; and storage means, connected to the discharge means, for storing the waste solution and the gas discharged from the discharge means; wherein the waste solution and the gas are separated from each other in the storage means.

The second object of the present invention is to provide an coating apparatus, by which the quality of an application film is improved by controlling the temperature of the air flow supplied to the rear surface of the substrate to be processed during the application step, at constant.

According to the second object of the present invention, there is provided an coating apparatus comprising: means for holding an object to be process, the object holding means having drive means for rotating the object holding means in a state in which the object is placed thereon; a ring-shaped cup situated on an outer side of the object holding means; processing solution supply means, provided above the object, for supplying a processing solution on a surface of the object; clean air supply means for allowing cleaning air a temperature of which is adjusted, flow to the ring-shaped cup and a surrounding thereof, in a down-flow manner; cooling-heat insulating means mounted so as to cover at least a part of an outer side surface of the drive means; and cleaning air guide means for allowing the cleaning air to flow from an outer side of the ring-shaped cup to an inner side of the ring-shaped cup through an underneath portion of the ring-shaped cup, so as to supply the cleaning air to a rear surface of the object placed on the object holding means.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention and, together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. **1** is a schematic cross section showing an entire structure of a conventional resist coating apparatus;

FIG. **2** is a diagram designed to describe the speed control of the spin chuck in the conventional resist coating apparatus shown in FIG. **1**;

FIG. **3** is a schematic plan view showing the structure of the conventional resist coating apparatus shown in FIG. **1**;

FIG. **4** is a side view showing the structure of a joint mechanism between the resist nozzle scan arm and the nozzle holder in the conventional resist coating apparatus shown in FIG. **1**;

FIG. **5** is a plan view showing the entire structure of the application development process system including a resist

application unit (apparatus) according to an embodiment of the present invention;

FIG. **6** is a front view showing the structure of the application development processing system shown in FIG. **5**;

FIG. **7** is a rear view showing the structure of the application development processing system shown in FIG. **5**;

FIG. **8** is a schematic front view illustrating the flow of the cleaning air in the application development processing system shown in FIG. **5**;

FIG. **9** is a schematic side view illustrating the flow of the cleaning air in the application development processing system shown in FIG. **5**;

FIGS. **10** and **11** are schematic plan views showing an entire structure of the resist application unit in the embodiment of the present invention;

FIG. **12** is a diagram illustrating an example of the speed control of the spin chuck in the resist application unit of the embodiment of the present invention;

FIG. **13** is a perspective diagram showing the structure of the nozzle holder in the resist application unit of the embodiment of the present invention;

FIG. **14** is a cross section showing the structure of the nozzle holder in the resist application unit of the embodiment of the present invention;

FIG. **15** is a cross section showing the state in which the resist nozzle is set on the rinse nozzle scan arm in the resist application unit of the embodiment of the present invention;

FIGS. **16A** and **16B** are cross sections showing the structure of the joint mechanism between the resist nozzle scan arm and the nozzle holder, in the resist application unit of the embodiment of the present invention; and

FIG. **17** is a cross section showing the structure of the fixation mechanism of the nozzle holder used in the resist application unit according to the embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the coating apparatus according to the first aspect of the present invention, the separation of the waste solution and the gas exhausted is not carried out in the ring-shaped cup, and the waste solution and the gas exhausted are sent together via exhaustion means to storage means, in which the waste solution and the exhaustion gas are separated from each other by gas-solution separation means. With this constitution, the waste solution is prevented from being solidified in the cup, and therefore the stuffing up of the system or the like can be suppressed.

In the coating apparatus according to the second aspect of the present invention, cleaning air having a constant temperature and supplied in a down-flow manner, detours from the outer side of the cup around the underneath area of the cup, to the inner side thereof, and after ascending a region close to the driving means, the cleaning air flows along the rear surface of the object from the inner side of the substrate towards the outer side. At this time, due to the cooling or heat insulating effect of cooling-heat insulating means provided so as to cover at least a part of the outer side surface of the driving means, the cleaning air is supplied to the rear surface of the object while maintaining its temperature substantially at constant, without being warmed by the heat of the drive means when the air flows near the drive means. With this constitution, the object is not heated by the air flow which hits the rear surface of the object, thus achieving a high quality application film.

The coating apparatus of the present invention includes means for controlling the rotation of the object holding means, which curvedly changing the rotation speed along with the time axis when changing the rotation speed of the object holding means. Therefore, when changing the rotation speed of the object holding means, for example, while increasing the rotation speed, the rotation speed is changed curvedly along the time axis, for example, in an S-shaped manner. Consequently, the stress created between the object holding means and the object is relaxed, or the sliding therebetween can be avoided, thus preventing the generation of particles.

Further, in the coating apparatus of the present invention, a recess portion is formed on an upper surface of the processing solution supply means holder for holding processing solution supplying means, and the first joint portion is provided in this recess portion. Further, a tweezer member having the second joint portion which can be jointed to the first joint portion in the recess portion, the tweeze member being capable of entering/exiting the recess portion of the processing solution supply means holder in the vertical direction, is provided for the processing solution supplying means conveying means for moving the processing solution supplying means between the standby position and the processing solution discharge position set above the object holding means. With this structure, even if particles are created due to friction when the second joint portion of the tweezer member of the processing solution supply means conveying means is attached to or detached from the first joint portion of the recess portion of the solution, such particles are captured within the recess portion, thus preventing the particles from scattering around. As a result, the creation of particles between the processing solution supplying means and the processing solution supplying means conveying means can be prevented.

Furthermore, in the coating apparatus of the present invention, there are provide a movable arm for supporting the processing solution supplying means and arm driving means for translationally moving the arm in order to move the processing solution supplying means between the standby position and the processing solution discharge position set above the object on the object holding means. With this structure, the processing solution supplying means is moved by translationally moving the arm. Therefore, even if the moving distance of the arm contains an error due to a backlash or the like in the driving mechanism, an error which is larger than the error contained in the moving distance is not caused in the position of the processing solution supplying means, thus achieving a position of the processing solution supplying means at the processing solution discharge position at a practically sufficient accuracy. Therefore, it is rendered possible to hit the processing solution at the peripheral portion of the object for an accurate width, improving the processing accuracy.

With regard to the coating apparatus of the present invention, examples of the object are a wafer, an LCD (liquid crystal device) substrate, a CD, a hard disk and ceramic substrate, and examples of the processing solution are a resist solution and magnetic solution. Further, an example of the object holding means is a type in which a processing solution is spread over the surface of an object by a centrifugal force created while rotating the object on a spin chuck or the like. Furthermore, an example of the processing solution supplying means is a nozzle.

An embodiment of the present invention will now be described with reference to FIGS. **5** to **16B**. First, with

reference to FIGS. **5** to **9**, an application development processing system including a resist coating apparatus, which is an embodiment of the present invention, will now be explained. FIGS. **5** to **7** are diagrams showing an entire structure of an application development processing system. FIG. **5** is a plan view thereof, FIG. **6** is a front view thereof and FIG. **7** is a rear view.

This processing system has a structure in which a cassette station **10** for loading or unloading a plurality of wafers W which are objects, for example, in the unit of 25, by means of wafer cassettes CR, and for loading or unloading wafers W on/from a wafer cassette CR, a processing station **12** in which various one-by-one type processing units each carrying out a predetermined process on wafers W one by one in the application development step are provided stepwise at predetermined positions, and an interface portion **14** for passing or receiving wafers W with respect to an exposure device (not shown) located adjacent to the processing station **12**, are integrally connected.

In the cassette station **10**, as shown in FIG. **5**, a plurality of, for example, up to **4** wafer cassettes CR, are placed at positions of projections **20***a* on a cassette placement base **20** in one line in an X direction with each wafer inlet/outlet facing the processing station **12**. A wafer conveying means **22** movable in the cassette arrangement direction (X direction) and in the wafer arrangement direction (Z vertical direction) for wafers loaded in a wafer cassette CR, is designed so as to be able to selectively access to each wafer cassette CR. Further, the wafer conveying member **22** is designed so as to be rotatable in the θ direction, and can access to an alignment unit (ALIM) and an extension unit (EXT) which belong to a multi-story unit portion of the third group G3 on the process station **12** side, as will be described later.

In the processing station **12**, as can be seen in FIG. **5**, a main wafer conveying mechanism **24** of a vertical conveying type is provided at the center portion thereof. Around the mechanism **24**, all the processing units are provided multi-storied in one group or a plurality of groups. An example thereof is a multi-story arrangement structure of five groups G1, G2, G3, G4 and G5. More specifically, a multi-story unit of the first and second groups G1 and G2 is juxtaposed in the front side of the system (foreground side in FIG. **5**), a multi-story unit of the third group G3 is placed adjacent to the cassette station **10**, a multi-story unit of the fourth group G4 is placed adjacent to the interface portion **14**, and a multi-story unit of the fifth group G5 is placed on the rear side of the system.

As can be seen in FIG. **6**, in the first group G1, a resist application unit (COT) and a development unit (DEV) according to the present embodiment as a spinner-type processing unit for carrying out a predetermined process while a wafer W being placed on the spin chuck in the cup CP, are placed one above another in two stories from below in the order. Similarly, in the second group G2, a resist application unit (COT) and a development unit (DEV) according to the present embodiment are placed one above another in two stories from below in the order. In the resist application unit (COT), the process of the waste of the resist solution is very much laborious in terms of not only mechanism but also maintenance, and therefore it is preferable that the resist application unit (COT) should be placed in a lower story. It should be noted that the resist application unit (COT) can be placed at a higher story in accordance with necessity.

As can be seen in FIG. **7**, in the third group G3, oven-type processing units for carrying out predetermined processes on a wafer W placed on a stage SP, for example, a cooling unit (COL), an adhesion unit (AD), an alignment unit (ALIM), an extension unit (EXT), pre-baking units (PREBAKE) and post-baking units (POBAKE) are placed one on another in eight stories the in the order from below. Similarly, in the fourth group G4, oven-type processing units, for example, a cooling unit (COL), an extension-cleaning unit (EXTCOL), an extension unit (EXT), a cleaning unit (COL), pre-baking units (PREBAKE) and post-baking units (POBAKE) are placed one on another in eight stories the in the order from below.

As described above, the cleaning unit (COL) and the extension-cooling unit (EXTCOL) which have low processing temperatures are placed in lower stories, whereas the baking units (PREBAKE), the post-baking units (POBAKE) and the adhesion unit (AD) are placed in higher stories, thus lowering the thermal interference between units. It should be noted that units having low processing temperatures and units having high processing temperatures can be arranged at random in stories in accordance with necessity.

The interface portion **14** has the same measurements as those of the processing station **12** in terms of its depth direction, and has a smaller measurement than that of the processing station **12** in its width direction. On the front side of the interface portion **14** (the bottom side in FIG. **5**), a portable pick-up cassette CR and a stationary buffer cassette BR are arranged in two stories. On the rear surface side (the upper side of FIG. **5**), a periphery exposure device **28** is provided, and at the center portion, a wafer conveying member **26** is provided. The wafer conveying member **26** is designed to move in the X and Z directions so as to access both cassettes CR and BR and the periphery exposure device **28**. Further, the wafer conveying member **26** is formed rotatable in the θ direction so as to be able to access the extension unit (EXT) which belongs to the multi-story unit of the fourth group G4 on the processing station **12** side, and also a wafer transfer stage (not shown) located adjacent thereto.

The processing system is provided in a clean room, and also within the system, the degree of cleanness of each member is increased by a high efficiency vertical layer flow mode. FIGS. **8** and **9** show flows of clean air in the system.

As can be seen in FIGS. **8** and **9**, above the cassette station **10**, the processing station **12** and the interface portion **14**, air supply chambers **12***a*, **14***a* and **16***a* are provided. On the lower surfaces of these air supply chambers **12***a*, **14***a* and **16***a*, filters with dust-proof function, for example, ULPA filters **30**, **32** and **34** are mounted.

As shown in FIG. **9**, outside or in the back of the present processing system, an air conditioner **36** is provided. Air is introduced from the air conditioner **36** to the air supplying chambers **12***a*, **14***a* and **16***a* via a pipe **38**. Clean air is supplied from the ULPA filters **30**, **32** and **34** of the air supplying chambers to the members **10**, **12** and **14** in down flow. The down flow air is guided to an exhaustion opening **42** provided at the bottom, via a number of ventilation holes provided at appropriate sections in the lower portion of the system, and thus the air is collected from the exhaustion opening **42** via the pipe **44** into the air conditioner **36** so as to be circulated. It is also possible that the air is discharged to the outside from the exhaustion opening **42** without being circulated. Note that, as can be seen in FIG. **8**, in the cassette station **10**, a space above the cassette placement base **20** and a space in which the wafer conveying arm **22** is moved, are separated from each other by a hanging-wall type partition plate **11**, thus the down flows of the air in these spaces being different from each other.

As shown in FIGS. **8** and **9**, in the processing station **12**, a ULPA filter **46** is provided on a ceiling surface of the resist application unit (COT) provided at a lower story of the multi-story unit of the first and second groups G1 and G2, and the air from the air conditioner **36** is sent to the filter **46** via a pipe **48** branched from the pipe **38**. In the middle of the pipe **48**, a temperature-humidity controller (not shown) is provided so that clean air having a predetermined temperature and a predetermined humidity, suitable for the resist application step, can be supplied to the resist application unit (COT). Further, a temperature-humidity sensor **50** is provided near the flow-out side of the filter **46**. An output from the sensor is supplied to the control portion of the temperature-humidity adjuster, and the temperature and humidity of the clean air are accurately controlled by a feedback mode.

In FIG. **8**, an opening portion DR through which a wafer and the conveying arm are allowed to pass, is provided on the side walls of the spinner-type processing units (COT) and (DEV) which face the main wafer conveying mechanism **24**. Each opening DR has a shutter (not shown) mounted thereto, so that particles or contaminant are not allowed to enter the main wafer conveying mechanism **24**.

In the application development processing system of the structure, wafers W are conveyed, for example, as follows in order to carry out the processes. First, wafers W before the process are unloaded one by one from a wafer cassette CR by means of the wafer conveying member **22**, and each wafer W is loaded to an alignment unit (ALIM). Then, a wafer W which has been aligned is unloaded by means of the main wafer conveying mechanism **24**, and loaded to the adhesion unit (AD), where the wafer W is subjected to an adhesion process. After completion of the adhesion process, the wafer W is unloaded by the main wafer conveying mechanism **24**, and conveyed to the cooling unit (COL), where the wafer W is cooled. Next, the wafer W is sent to the resist application unit (COT), the prebaking unit (PREBAKE) and the extension cooling unit (EXTCOL), in each of which the wafer is subjected to each predetermined process, and then the wafer W is conveyed via the interface portion **14** to the exposure device. After the wafer W is subjected to the exposure process, the wafer W is conveyed to the extension unit (EXT), the development unit (DEV) and the post-baking unit (POBAKE) of the fourth group G4, the extension unit (EXT) of the third group G3 and the like, in each of which a certain process is carried out, and the wafer W which has been subjected to various processes, is conveyed and loaded to a wafer cassette CR.

Next, the resist application unit (COT) in the present embodiment will now be described with reference to FIGS. **10** to **16B**. FIGS. **10** and **11** are schematic cross section and plan view, respectively, showing an entire structure of the resist application unit (COT).

In the resist application unit (COT), a ring-shaped cup CP is provided at a central portion of the bottom of the unit, within which a spin chuck **52** is provided. The spin chuck **52** is designed so that it is rotated by the rotation driving force of the drive motor **54** serving as driving means, while fixedly holding a wafer W by vacuum suction. The drive motor **54** is provided ascendable/descendable at an opening **50***a* provided in the unit bottom plate **50**, and is coupled with ascending/descending drive means **60** made of, for example, an air cylinder and ascending/descending guide means **62** via a cap-like flange member **58** made of, for example, aluminum. On the side surface of the drive motor **54**, a cylindrical cooling jacket **64** made of, for example, SUS, is mounted, and the flange member **58** is mounted so as to cover the upper half portion of the cooling jacket **64**.

At the time of the resist application, as can be seen in FIG. **10**, a lower end **58***a* of the flange member **58** is tightly attached to the unit bottom plate **50** at the outer periphery of the opening **50***a*, thus sealing the unit. When a wafer W is transferred between the spin chuck **52** and the tweezers **24***a* of the main wafer conveying mechanism, the drive motor **54** and the spin chuck **52** are lifted up by the ascending/descending drive means **54**, and therefore the lower end of the flange member **58** is separated above from the unit bottom plate **50**. In the cooling jacket **64**, a water path for allowing cooling water to flow therethrough, is provided in the cooling jacket **64**, and the cooling water CW the temperature of which is adjusted to a constant level is circulated within the jacket from the cooling water supply portion (not shown).

Between the lower surface of the cup CP and the unit bottom plate **50**, a space **66** is provided. In the unit, cleaning air the temperature and humidity of which are controlled to be constant, is supplied in a down-flow manner from the ULPA filter **46** to the ceiling as described above. The cleaning air which hits the unit bottom plate **50** around the cup CP proceeds through a gap **66** underneath the cup CP to the inner side of the cup CP. In the resist application, the lower end **58***a* of the flange **58** is tightly attached to the unit bottom plate **50** near the periphery of the opening **50***a* so as to seal the unit, and therefore the cleaning air which has passed the space **66** to reach the inner side of the cup CP, ascends along the side surface of the flange member **58** as indicated by dotted line A, and enters the cup CP through the space **68** between the periphery of the wafer W and the cup CP. Thus, as the air flows through the space **68** from the inner side to the outer side, the resist solution is prevented from scattered around the edge and reaching the rear surface of the wafer.

The heat generated from the drive motor **54** is quickly absorbed by the cooling jacket **64**, and the flange member **58** covers around the cooling jacket **64**, and therefore the cleaning air which has passed the space **66** and flowed to the inner side of the cup CP, is not warmed while it is passing near the drive motor **54**. The cleaning air from the ULPA filter **46** of the ceiling detours underneath the cup CP while maintaining the temperature and the humidity substantially at constant, and reaches the space **68**. Consequently, the peripheral portion of the wafer W is not warmed by the air flow on the rear surface side, and thus the uniformity of the resist film is guaranteed.

In the cup CP, a chamber is defined by the outer peripheral wall surface, the inner peripheral wall surface and the bottom surface, and a drain opening **56** (or a plurality of them) is provided. The drain opening **56** is connected to a tank **72** via a drain pipe **70**. The tank **72** is a sealed container, on a bottom surface of which a waste solution opening **72***a* is provided, on an upper surface of which an exhaustion opening **72***b* is provided, and these openings are connected to a waste solution processing unit (not shown) and an exhaustion pump (not shown) via pipes **74** and **76**, respectively. Outside the tank **72**, solution surface sensors **78** and **80** for detecting a liquid surface in the tank, are set at positions of predetermined heights.

In the resist application, the resist solution portions scattered around from the wafer W are collected in the cup CP as indicated by a solid line B, and sent as a waste solution from the drain opening **56** at the bottom of the cup CP through the drain pipe **70** to the tank **72**. At the same time, the air present in the cup CP is also discharged as a waste gas from the drain opening **56** together with the waste solution. In the tank **72**, a solvent such as thinner is provided via a

pipe which is not shown, and the resist is temporarily stored in the tank in the form of a liquid without being solidified. When the liquid surface in the tank **72** rises up to the upper limit position, a control circuit (not shown) opens an open/close valve **82** of the pipe **74** in response to an output signal SH from the solution surface sensor **78**, whereas when the liquid surface in the tank **72** lowers down to the lower limit position, the control circuit closes the open/close valve **82** in response to an output signal SL from the solution surface sensor **80**. Thus, the waste solution from the cup CP is sent to the waste solution processing portion via the pipe **74** after being temporarily stored in the tank **72**. In the meantime, the gas sent to the tank **72** is discharged from the exhaustion opening **72***b* via the pipe **76** to the exhaustion pump side.

As described above, in the resist application unit according to the present embodiment, the separation of the solution and air is not performed in the cup CP, but the waste solution and the air are sent together from the cup CP via the common exhaustion opening **56** and the common drain pipe **70** to the tank **72**, in which the separation of the waste solution and the air (liquid-gas separation) is carried out. The resist solution portions sent from the cup CP are sucked by the negative pressure on the tank **72** side and vigorously fall into the solvent in the tank **72** by the effect of the centrifugal force, in which the solution portion collide with the solvent?? and collected. In the tank **72**, the mist of the resist does not float around very much, and therefore the stuffing of the exhaustion opening **72***b* and the pipe **76** with a solidified resist portion does not substantially occur. Even if the pipe is stuffed with a solidified resist portion, the cleaning of the exhaustion opening **72***b* and the pipe **76** is very simple.

The rotation speed of the spin chuck **52**, that is, the rotation speed of the drive motor **54**, is controlled by the spin chuck rotation control portion **84** under the control of a system controller (not shown). The spin chuck rotation control portion **84** is made of a servo controller, and serves to control the speed of the drive motor **54** so as to have a smooth curved characteristic along with time, for example, an S-shaped curve, when the rotation of the spin chuck **52** is started or stopped, as can be seen in, for example, FIG. **12**. In this manner, at a transition point of the rotation speed, an acceleration applied to the spin chuck **52** and the wafer W is small, and a sliding between them does not easily occur, thus preventing the generation of particles.

The resist nozzle **86** used for supplying a resist solution on the surface of a wafer W, is connected to a resist supply portion (not shown) via a resist supply tube **88**. The resist nozzle **86** is detachably mounted to the distal end of the resist nozzle scan arm **92** at the resist nozzle standby unit **90** provided outside the cup **100**, and conveyed to a predetermined resist solution discharge position set above the spin chuck **52**. The resist nozzle scan arm **92** is mounted to the upper end portion of the vertical supporter member **96** which can be horizontally moved on a guard rail **94** laid on the unit bottom plate **50** in one direction (Y direction), and the arm can be moved in the Y direction integrally with the vertical supporter member **96** by a Y direction drive mechanism (not shown). Further, the resist nozzle scan arm **92** is movable also in an X direction normal to the Y direction in order to selectively mount the resist nozzle **86** at the resist nozzle standby unit **90**, by means of an X direction drive mechanism.

In the resist application unit (COT) of the present embodiment, the discharge opening of the resist nozzle **86** is inserted to the opening **90***a* of the solvent atmosphere chamber at the resist nozzle standby unit **90**, and therefore the tip end of a nozzle is exposed to the atmosphere of the solvent in the chamber, thus preventing the solidification or the deterioration of the resist solution at the tip end. Further, a plurality of resist nozzles **86** are provided, and each nozzle can be separately used in accordance with each of various types of resist solutions.

At the resist nozzle standby unit **90**, according to its design, a plurality of resist nozzles **86** are arranged at a constant interval P, and the resist nozzle scan arm **92** moves at a pitch P' which corresponds to the interval **92** in order to pick up each resist nozzle. However, during the manufacture thereof or installation, the interval P between the resist nozzles **86** in some cases, drifts from what it should be. According to the present embodiment, in accordance with an error in the resist nozzle interval P, the movement pitch P' of the resist nozzle scan arm **92** is finely adjusted. For example, in the case where a pulse motor or a stepping motor is used as the drive motor for the X-direction drive mechanism, the number of pulses applied to the motor is adjusted by means of a software, in order to finely adjust the movement pitch P'.

With reference to FIGS. **13** to **16B**, the structure of the present embodiment, for detachably mounting the resist nozzle **86** to the resist nozzle scan arm **92**, will now be described. FIGS. **13** and **14** are a perspective view and a cross section, respectively, showing the structure of the nozzle holder **100** for holding the resist nozzle **86**. FIG. **15** is a side view showing the state in which the resist nozzle **86** is mounted on the tip end portion of the arm of the resist nozzle scan arm **92**. FIGS. **16A** and **16B** are partial cross sections showing the structure of the joint mechanism between the resist nozzle scan arm **92** and the nozzle holder **100**.

As can be seen in FIGS. **13** and **14**, the nozzle holder **100** is made of a thick plate member. On an upper surface and a lower surface of the plate member, a cylindrical pipe mounting portion **102** and a nozzle mounting portion **104** are respectively fixedly attached, and the mounting portions **102** and **104** are connected via a through hole **106**. The resist nozzle **86** is screwed on the nozzle mounting portion **104**, and the resist supply tube **88** is fit to the pipe mounting portion **102**. Further, on the lower surface of the nozzle holder **100**, a rod-like fixation member **108** to be fixedly fit to a fixation holder hole **90***b* of the resist nozzle standby unit **90**, and on the upper surface which is located on the opposite side of the fixation member **108**, a recess portion **110** for accepting the tweezers **92***a* and **92***b* of the resist nozzle scan arm **92** is provided. On the inner wall surface of the bottom portion of the recess **110**, a pair of grooves **110***a* and **110***b* which face to each other are formed as can be seen in FIGS. **16A** and **16B**.

As can be seen in FIG. **15**, a pair of openable tweezers **112** and **114** are mounted to a tweezer open/close drive mechanism (not shown) built in the tip end **92***a* of the resist nozzle scan arm **92**. As shown in FIG. **16A**, the tweezers **112** and **114** is designed to be able to enter the recess portion **110** of the nozzle holder **100** while they are in a closed position. At the tip ends of the tweezers **112** and **114**, nail portions **112***a* and **114***a* are formed. As can be seen in FIG. **16B**, when the tweezers **112** and **114** are opened within the recess portion **110**, the nail portions **112***a* and **114***a* are fit or engaged with the groove portions **110***a* and **110***b* of the recess portion **110**, so as to set or joint the nozzle holder **110** to the resist nozzle scan arm **92**. Thus, the resist nozzle **86** is mounted. In order to detach the resist nozzle **86**, the tweezers **112** and **114** are closed as can be seen in FIG. **16A**, and pulled out. It should be noted that in FIG. **15**, a reference numeral **116** indicates a cable for supplying a drive current to the tweezer open/

close drive mechanism in the tip end portion **92***a* of the arm, and a reference numeral indicates a pipe for discarding dust pieces in the arm by suction.

As described above, according to the present embodiment, in the recess portion **110** formed in the upper surface of the nozzle holder **100** for holding a resist nozzle **86**, the groove portions (the first joint portions) **110***a* and **110***b* in the recess portion **110** and the nail portions **112***a* and **114***a* (the second joint portions) at the tip ends of the tweezers **112** and **114** of the resist nozzle scan arm **92** are fit with each other, and thus the resist nozzle **86** is detachably set to the resist nozzle scan arm **92**. Even if both joint portions **110***a*, **110***b*, **112***a* and **114***a* are slid on each other, generating particles, when the setting or removing of the resist nozzle **86**, the particles are confined in the bottom of the recess portion **110** and not scattered around. It is also possible to provide a suction opening (not shown) around the tweezers **112** and **114**, so as to suck in the generated particles from the suction opening, and discard through the pipe **118**.

As shown in FIG. **11**, a vertical supporting member **122** which is movable in the Y direction and supports not only the vertical supporting member **96** for supporting the resist nozzle scan arm **92**, but also the rinse nozzle scan arm **120**, is also provided on the guide rail **94**. At the tip end portion of the rinse nozzle scan arm **120**, a rinse nozzle **124** for side rinse is mounted. The rinse nozzle scan arm **120** and the rinse nozzle **124** are allowed to move translationally or linearly between the nozzle standby position (indicated by a solid line) set on a side of the cup CP by the Y-direction drive mechanism (not shown) and the rinse solution discard position (indicated by a dotted line) set directly above the periphery portion of the wafer W placed on the spin chuck **52**. A servo type positioning member may be provided for the Y-direction drive mechanism for the rinse nozzle scan arm **120**. Since the positioning is carried out by a translational movement, even if an error occurs in the moving distance of the rinse nozzle scan arm **120** due to a backlash or the like, a further error which is worse than that which occurs in the moving distance error does not occur in the position of the rinse nozzle **122**. Therefore, the rinse nozzle **122** is positioned at an accuracy which is practically sufficient. Consequently, the side rinse can be carried out on the periphery portion of the wafer always W at a constant width.

In FIG. **11**, pipes (resist supply pipe **88** and rinse supply pipe) connected respectively to the resist nozzle **86** and the rinse nozzle **122** are not drawn in order to facilitate the illustration. Further, in FIGS. **10** and **11**, a shutter mounted to the opening portion DR through which the wafer-conveying tweezers **24***a* enters the unit, is not drawn.

The structures or shapes of the members, or the circuit structures in the above embodiment are examples, and can be remodeled into a number of variations. For example, according to the above embodiment, the nail portions **112***a* and **114***a* are provided on the tweezers **112** and **114** of the arm **92**, and the groove portions **110***a* and **110***b* are provided in the recess portion **110** of the nozzle holder **100** so that they are jointed with each other in the joint mechanism between the resist nozzle scan arm **92** and the nozzle holder **100**; however it is also possible that, reversely, the groove portions are provided on the tweezers **112** and **114**, and the nail portions or projections are provided in the recess portion, so as to joint them together. In the meantime, in place of using the projecting fixation member **108** in order to fix the nozzle holder **100** to the resist nozzle standby portion **90**, it is also possible that the nozzle holder **100** is fixed to the resist nozzle standby unit **90** by means of a press member **108**A as can be seen in FIG. **17**. More specifically, a press member **108** having an L-letter shape, and formed rotatable around a rotation shaft **108**C mounted to an end portion of a mounting member **108**B fixed to the resist nozzle standby portion, is set, and the press member **108** is rotated as indicated by an arrow by means of a rotation mechanism (not shown) which uses an air cylinder, a motor or the like. In the standby state, the member **108**A is rotated in the counter-clockwise direction, so as to press the upper end portion of the nozzle holder **100** by a tip end portion **108**D, thus fixing the holder to the resist nozzle standby portion **90**. When using the nozzle, the press member **108**A is rotated in the clockwise direction, so as to render the nozzle holder in a removable state. When there are a plurality of nozzle holders **100**, the press member **108**A is provided for each of the holders **100**, and the press members should be designed independently operable. Further, the above embodiment is directed to an apparatus for applying a resist solution to a wafer; however the present invention can be applied to an apparatus for applying a processing solution to a different object to be process.

As described above, according to the first coating apparatus of the present invention, the waste solution and the gas are separated in the storage means outside the cup used for collecting the processing solution scattered around when the solution is supplied to an object, and therefore, the cleaning of the cup is not necessary, improving the maintenance property.

Further, according to the second coating apparatus of the present invention, the cleaning air which is supplied in a down flow manner and the temperature of which is adjusted, is rendered detour underneath the cup, so that the cleaning air can be supplied to the rear surface of the object without being influenced by the heat generated from the drive means, thus making it possible to improve the quality of the application film.

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention and, together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

What is claimed is:

1. A processing apparatus using a solution, comprising:

means for holding an object to be processed, said means rotating with the object placed thereon;

a ring-shaped cup situated at an outer side of said object holding means;

processing solution supply means provided above said object for supplying a processing solution on a surface of said object;

discharging means provided below said ring-shaped cup for discharging, as a waste solution, together with air in said cup, processing solution portions scattered around when said processing solution is supplied on the surface of said object; and

storage means connected to said discharge means for storing said waste solution and said gas discharged from said discharge means and for separating said waste solution and said gas from each other therein.

2. A processing apparatus according to claim **1**, further comprising means for controlling a rotation of said object holding means, said controlling means comprising means for changing the rotation speed of said object holding means gradually.

3. A processing apparatus according to claim 1, including a holder having a recess portion in an upper surface thereof

for holding said processing solution supply means, and means for conveying said processing solution supply means between a standby position thereof and a processing solution discharge position set above said object holding means, wherein a first joint is provided in said recess portion, and said processing solution supply means conveying means can enter and exit said recess portion in a vertical direction and includes a tweezer member having a second joint portion which can be jointed to said first joint portion within said recess portion.

4. A processing apparatus according to claim **1**, further comprising a movable arm for supporting said processing solution supply means, and arm drive means for translationally moving said arm in order to convey said processing solution supply means between a standby position thereof and a processing solution discharge position set and above said object holding means.

5. A processing apparatus according to claim **1**, wherein said storage means includes a solution surface detection means for detecting a solution surface of said waste solution.

6. A processing apparatus according to claim **1**, wherein said storage means includes a gas discharge pipe for discharging said gas and a waste solution discharge pipe for discharging said waste solution.

7. A processing apparatus according to claim **6**, wherein said gas discharge pipe is located above said waste solution discharge pipe.

8. A processing apparatus with use of a solution according to claim **1**, further comprising means for creating a negative pressure in said storage means.

9. A processing apparatus using a solution, comprising:

means for holding an object to be processed, said object holding means having drive means for rotating said object holding means with the object placed thereon;

a ring-shaped cup situated on an outer side of said object holding means;

processing solution supply means, provided above said object, for supplying a processing solution on a surface of said object;

clean air supply means for allowing clean air, a temperature of which is adjusted, to flow to said ring-like cup and a surrounding area thereof, in a down-flow manner;

means mounted so as to cover at least a part of an outer side surface of said drive means for substantially preventing transfer of heat from said drive means; and

clean air guide means for allowing said cleaning air to flow from an outer side of said ring-shaped cup to an inner side of said ring-like cup through an underneath portion of said ring-like cup, so as to supply said cleaning air to a rear surface of the object placed on said object holding means.

10. A processing apparatus according to claim **9**, further comprising means for controlling a rotation of said object holding means, said controlling means comprising means for changing the rotation speed of said object holding means gradually.

11. A processing apparatus according to claim **9**, including a holder having a recess portion in an upper surface thereof for holding said processing solution supply means and means for conveying said processing solution supply means between a standby position thereof and a processing solution discharge position set above said object holding means, wherein a first joint is provided in said recess portion, and said processing solution supply means conveying means can enter and exit said recess portion in a vertical direction and includes a tweezer member having a second joint portion which can be jointed to said first joint portion within said recess portion.

12. A processing apparatus according to claim **9**, further comprising a movable arm for supporting said processing solution supply means, and arm drive means for translationally moving said arm in order to convey said processing solution supply means between a standby position thereof and a processing solution discharge position set above said object holding means.

13. A processing apparatus according to claim **9**, further comprising temperature and moisture detecting means for detecting temperature and moisture of said cleaning air.

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